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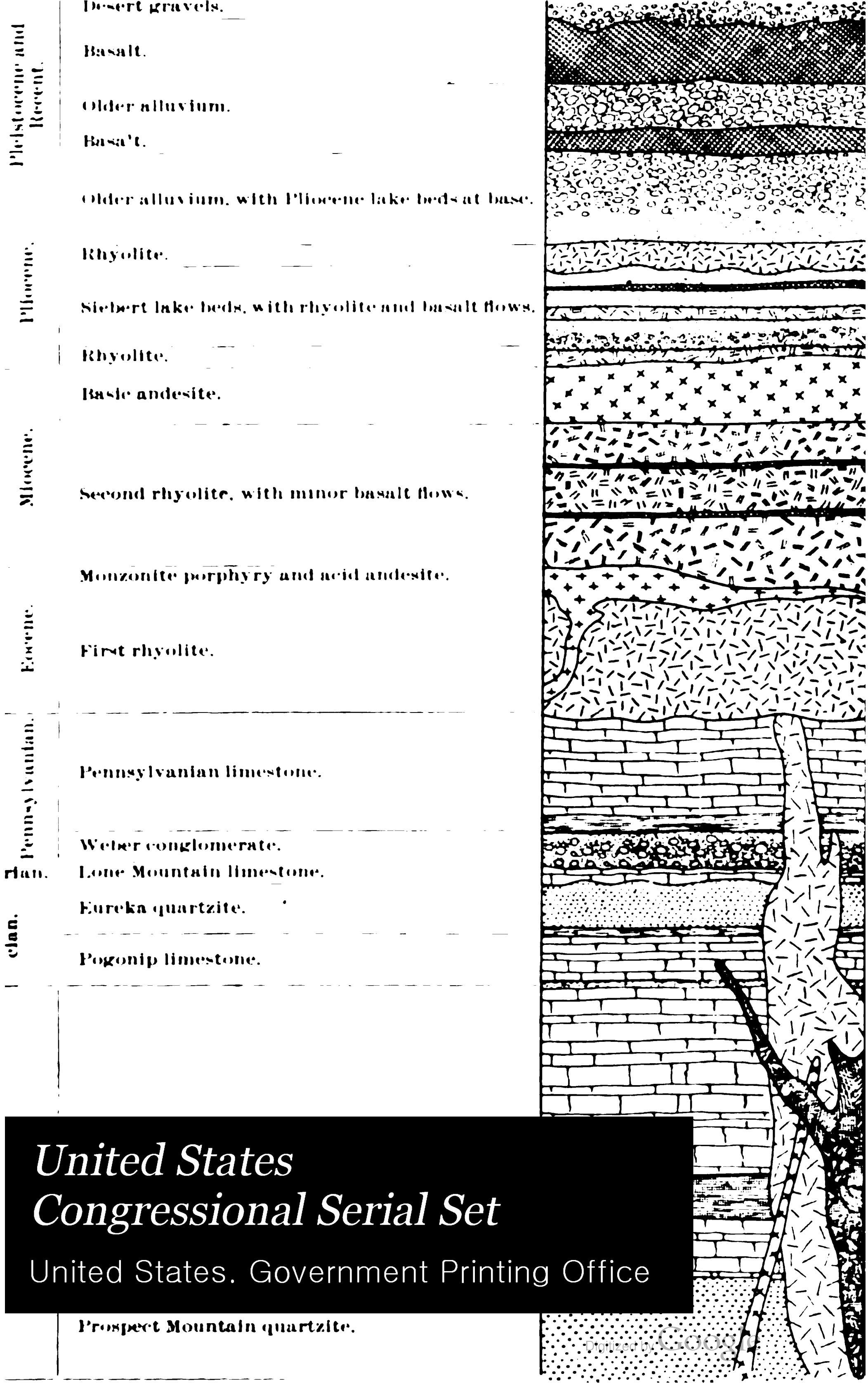

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CONTENTS

No.

61. Geological Survey, bulletin 308; geologic reconnaissance in southwestern Nevada and eastern California.

62. same, 309; Santa Clara Valley, Puente Hills, and Los Angeles oil districts.

63. same, 310; results of primary triangulation and primary traverse, 1906.

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Bulletin No. 308 Series { A, Economic Geology, 90
B, Descriptive Geology, 111

DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY
CHARLES D. WALCOTT, DIRECTOR

A GEOLOGIC RECONNAISSANCE IN SOUTHWESTERN NEVADA AND EASTERN CALIFORNIA

BY

SYDNEY H. BALL

WASHINGTON
GOVERNMENT PRINTING OFFICE
1907

CONTENTS.

Page.

Introduction — 13
  Field work and acknowledgments — 13
  Location and area — 14
  Literature — 15
  The Great Basin — 16
  Topography — 16
  Climate — 17
Hydrology — 18
  General statement — 18
  Streams — 18
  Springs — 19
    Hot or warm springs — 19
    Cold springs — 20
  Tanks — 21
  Wells — 21
  Snow — 22
  Signs of water — 22
Animal life — 23
Vegetation — 23
Culture — 24
  Industries — 24
  Towns — 25
  Railroads and stages — 26
  Roads and trails — 26
Stratigraphic geology — 26
  Pre-Cambrian — 26
  Cambrian — 28
  Ordovician and Silurian — 28
  Devonian — 29
  Carboniferous — 30
  Post-Jurassic and pre-Tertiary igneous rocks — 30
  Tertiary — 31
  Pleistocene and Recent — 35
    Travertine — 35
    Desert gravels — 35
    Playa deposits — 36
    Sand dunes — 36
  Definitions of igneous rocks — 37
Geologic history — 38

Page.
Economic geology 42
  History of mining development 42
  Economic conditions 43
  General character of the ore deposits 44
    Post-Jurassic and pre-Tertiary deposits 44
      Deposits in granite 44
      Deposits in Palezoic sedimentary rocks, predominantly limestone 44
    Tertiary deposits 46
      Gold deposits in silicified monzonite porphyry and related rocks 46
      Deposits in rhyolite 46
  Aids to prospecting 49
Descriptive geology 50
  Region about Goldfield 50
    Lone Mountain foothills 51
      Topography and geography 51
      General geology 51
        Sedimentary rocks 51
          Cambrian 51
          Older alluvium 52
        Igneous rocks 52
          Granite 52
          Diorite and diorite porphyry 53
      Structure 54
      Economic geology 54
    Northeastern extension of the Silver Peak Range 55
      Topography and geography 55
      General geology 56
        Sedimentary rocks 56
          Cambrian 56
          Siebert lake beds 57
          Travertine 58
        Igneous rocks 58
          Post-Jurassic granite, granite porphyry, and quartz-monzonite porphyry 58
          White quartz-monzonite porphyry 60
          Diorite porphyry 60
          Andesite 61
          Rhyolites and dacites 61
          Later rhyolite 62
          Basalt 62
      Structure 62
      Economic geology 63
        Montezuma district 63
        Lida 64
        Other mineralized areas 65
        Lime 65
    Lida-Goldfield Valley 65
    Mount Jackson and the hills to the northeast 66
      Topography and geography 66

Descriptive geology—Continued. Page.
Region about Goldfield—Continued.
Mount Jackson and the hills to the northeast—Continued.

- General geology 66
  - Sedimentary rocks 66
    - Cambrian 66
    - Siebert lake beds 67
  - Igneous rocks 67
    - Diorite porphyry 67
    - Rhyolite 67
    - Basalt 68
- Structure 68
- Economic geology 69

Valley north of Slate Ridge 71
Goldfield hills 71
- Topography and geography 71
- General geology 72
  - Sedimentary rocks 72
    - Siebert lake beds 72
    - Later tuffs 72
  - Igneous rocks 73
    - Post-Jurassic granite 73
    - Andesite and dacite 73
    - Quartz latite and rhyolite 73
    - Quartz basalt 74
    - Later rhyolite 74
    - Basalt 75
- Structure 76
- Economic geology 76

Alkali Spring Flat 76
Southern Klondike hills 77
- Topography and geography 77
- General geology 77
  - Sedimentary rocks 77
    - Cambrian 77
    - Siebert lake beds 78
    - Older alluvium 78
  - Igneous rocks 78
    - Post-Jurassic granite 78
    - Earlier rhyolite 78
    - Earlier quartz latite 79
    - Basalt 79
    - Later rhyolite 80
    - Later quartz latite 80
- Structure 80
- Economic geology 81
  - Gold and silver 81
  - Iron ores 82

Ralston Valley 83
Stonewall Flat 83
Stonewall Mountain 83
- Topography and geography 83
- General geology 84

Descriptive geology—Continued. Page.

Region about Goldfield—Continued.

Stonewall Mountain—Continued.

General geology—Continued.

Sedimentary rocks 84
Cambrian 84
Siebert lake beds 84
Igneous rocks 84
Post-Jurassic granite and granite porphyry 84
Earlier rhyolite 85
Quartz syenite and quartz-monzonite porphyry 85
Later rhyolite 86
Basalt 87
Structure 87
Economic geology 88
Ranges north of Pahute Mesa 89
Cactus Range 89
Topography and geography 89
General geology 89
Sedimentary rocks 89
Pogonip limestone 89
Eureka quartzite 90
Weber conglomerate 90
Igneous rocks 90
Post-Jurassic granite porphyry and granite 90
Pre-Tertiary diorite porphyry 91
Hornblende-biotite latite 91
Earlier rhyolite 92
Biotite andesite 93
Augite andesite 94
Later rhyolite(?) 94
Basalt 94
Structure 94
Economic geology 95
Hills between the Cactus and Kawich ranges 96
Topography and geography 96
General geology 96
Sedimentary rocks 96
Eureka(?) quartzite 96
Igneous rocks 96
Rhyolite 96
Biotite andesite 96
Basalt 96
Monitor Hills 97
General geology 97
Sedimentary rocks 97
Siebert lake beds 97
Igneous rocks 97
Granite 97
Rhyolite 97
Basalt 97
Structure 98
Cactus Flat 98
Gold Flat 98

Descriptive geology—Continued.

Page.

Ranges north of Pahute Mesa—Continued.

Kawich Range 99
  Topography and geography 99
  General geology 100
    Sedimentary rocks 100
      Pogonip limestone and Eureka quartzite 100
      Lone Mountain limestone 102
      Siebert lake beds (?) 102
    Igneous rocks 103
      Post-Jurassic granite 103
      Diorite porphyry 103
      Monzonite porphyry 103
      Earlier rhyolite 104
      Earlier basalt 105
      Biotite andesite 106
      Dacite 106
      Later rhyolite 107
      Later basalt and associated andesites 107
  Structure 108
  Economic geology 108
    Silverbow 109
    Blakes Camp 110
    Eden 110
    Kawich 111
    Southern Kawich 113
    Areas favorable to prospecting 113
Reveille Valley 114
Kawich Valley 114
Reveille Range 114
  Topography and geography 114
  General geology 115
    Sedimentary rocks 115
      Weber conglomerate 115
      Pennsylvanian limestone 115
    Igneous rocks 116
      Rhyolite 116
      Basalt 116
  Structure 117
  Economic geology 117
Railroad Valley 118
Belted Range 118
  Topography and geography 118
  General geology 119
    Sedimentary rocks 119
      Pogonip limestone 119
      Weber conglomerate 120
      Pennsylvanian limestone 121
      Siebert lake beds 122
    Igneous rocks 123
      Monzonite 123
      Granite 123
      Andesite 125

Descriptive geology—Continued. Page.

Ranges north of Pahute Mesa—Continued.

Belted Range—Continued.

General geology—Continued.

Igneous rocks—Continued.

Earlier rhyolite 125
Later rhyolite 127
Basalt 127
Structure 128
Economic geology 128
Oak Spring 128
Other areas 130
Pahute Mesa 131
Topography and geography 131
General geology 131
Metamorphic rocks 132
Mica schists 132
Sedimentary rocks 132
Paleozoic quartzite 132
Siebert lake beds 132
Later tuffs 132
Recent desert gravels 133
Igneous rocks 133
Pre-granite monzonite 133
Post-Jurassic granite 133
Earliest rhyolite 135
Biotite andesite 135
Middle rhyolite 136
Latest rhyolite 136
Basalt 137
Structure 137
Economic geology 137
Trappmans Camp 138
Wilsons Camp 139
Gold Crater 139
Other areas 140
Tolicha Peak and Quartz Mountain 141
Topography and geography 141
General geology 141
Sedimentary rocks 141
Cambrian(?) schist 141
Igneous rocks 141
Structure 142
Economic geology 142
Mountains southeast of Pahute Mesa 142
Shoshone and Skull mountains and the hills in the vicinity 142
Topography and geography 142
General geology 143
Sedimentary rocks 143
Pennsylvanian limestone 143
Siebert lake beds 143
Igneous rocks 144
Quartz-monzonite porphyry 144
Earlier rhyolite 145

Descriptive geology—Continued. Page.
  Mountains southeast of Pahute Mesa—Continued.
    Shoshone and Skull mountains and the hills in the vicinity—Con.
      General geology—Continued.
        Igneous rocks—Continued.

          Later rhyolite 145
          Basalt 146
      Structure 147
      Economic geology 147
    Specter Range and Skeleton Hills 147
      Topography and geography 147
      General geology 148
        Sedimentary rocks 148
          Prospect Mountain quartzite 148
          Prospect Mountain limestone 148
        Igneous rocks 149
      Structure 149
      Economic geology 150
    Yucca Mountain 150
      Topography and geography 150
      General geology 150
          Post-Jurassic pegmatite 151
          Rhyolite and latite 151
          Basalt 151
      Structure 152
      Economic geology 152
    Timber Mountain 153
      Topography and geography 153
      Geology 153
          Rhyolite 153
          Basalt 153
    Bare Mountain 153
      Topography and geography 153
      General geology 154
        Paleozoic sedimentary rocks 154
        Igneous rocks 155
          Post-Jurassic pegmatites 155
          Diorite porphyry 156
          Tertiary rhyolite and basalt 156
      Structure 156
      Economic geology 156
  Sarcobatus Flat 157
  Amargosa Desert 158
  Amargosa mountain system 160
    Amargosa Range 160
      Topography and geography 160
      General geology 162
        Sedimentary rocks 162
          Prospect Mountain quartzite (?) 162
          Pogonip limestone 164
          Eureka quartzite 165
          Lone Mountain limestone 165
          Siebert lake beds and contemporaneous deposits 165
          Older alluvium 166

Descriptive geology—Continued. Page.

- Amargosa Mountain system—Continued.
  - Amargosa Range—Continued.
    - General geology—Continued.

- Igneous rocks 167
  - Granite porphyry 167
  - Diorite porphyry 167
  - Biotite andesite 167
  - Earlier rhyolite 168
  - Earlier basalt 170
  - Later rhyolite and biotite latite 170
  - Later basalt 171
- Structure 172
- Economic geology 173
  - Happy Hooligan mine 173
  - Chloride Cliff 173
  - Lee's Camp 175
  - Areas favorable for prospecting 175
- Bullfrog Hills 176
  - Topography and geography 176
  - General geology 176
    - Sedimentary rocks 177
      - Pre-Silurian schist 177
      - Eureka quartzite 177
      - Lone Mountain limestone 178
      - Siebert lake beds 178
      - Older alluvium 178
    - Igneous rocks 178
      - Post-Jurassic pegmatite and alaskite 178
      - Pre-Tertiary diorite porphyry 179
      - Biotite andesite 179
      - Rhyolite 180
      - Earlier basalt 181
      - Later basalt 181
  - Structure 181
  - Economic geology 182
- Gold Mountain ridge and the hills to the north of Grapevine Canyon 182
  - Topography and geography 182
  - General geology 183
    - Sedimentary rocks 183
      - Cambrian 183
    - Igneous rocks 184
      - Quartz-monzonite porphyry 184
      - Post-Jurassic granite 184
      - Diorite porphyry 186
      - Rhyolite 186
      - Basalt 186
  - Structure 187
  - Economic geology 187
    - Old Camp 188
    - Tokop 189
    - Oriental Wash 190

Descriptive geology—Continued.

Page.

Amargosa Mountain system—Continued.

Slate Ridge 191
  Topography and geography 191
  General geology 191
    Sedimentary rocks 191
      Cambrian 191
      Later tuffs 192
    Igneous rocks 192
      Post-Jurassic granite 192
      Pre-Tertiary quartz-monzonite porphyry 193
      Pre-Tertiary diorite porphyry 193
      Earlier rhyolite 193
      Later rhyolite 193
      Basalt 194
  Structure 194
  Economic geology 194
Death Valley 195
  Topography and geography 195
  General geology 197
    Sediments 197
      General statement 197
      Tertiary lake beds (including Siebert lake beds) 198
      Older alluvium 199
  Geologic history 200
  Economic geology 201
Panamint Range 201
  Topography and geography 201
  General geology 202
    Sedimentary rocks 202
      Prospect Mountain (?) quartzite 202
      Pogonip limestone 202
      Pennsylvanian limestone 203
      Older alluvium 204
      Recent alluvium 204
    Igneous rocks 205
      Earlier quartz-monzonite porphyry 205
      Quartz monzonite 205
      Soda syenite 207
      Granite 208
      Later quartz-monzonite porphyry 208
      Diorite porphyry 208
      Basalt 209
  Structure 210
  Economic geology 211
Index 213

ILLUSTRATIONS.

Page.

PLATE I. Geologic map of an area in southwestern Nevada and eastern California 26
II. A, Pahute Mesa, showing benches determined by resistant flows of basalt; B, Death Valley, showing sand dunes protected by desert shrubbery (mesquite and creosote bush) 36
III. Marble Canyon, Panamint Range, showing metamorphosed Pogonip limestone near quartz-monzonite batholith 200
FIG. 1. Index map showing location of area in southwestern Nevada and eastern California 14
2. Profile across Sarcobatus Flat and Amargosa Desert, showing relation of ground-water level to surface 21
3. Columnar section of rocks of southwestern Nevada and eastern California 27
4. Economic map showing areas of altered Tertiary rocks 43
5. Flow folds in rhyolite (hill 10 miles east of north of Mount Jackson), showing thickening of more glassy rhyolite (white) on crests and troughs of folds and cross fractures in more lithoidal rhyolite on limbs of folds 68
6. East-west section across Mount Jackson hills 1 mile south of halfway station 68
7. Section across north face of Stonewall Mountain through Stonewall Spring 88
8. East-west section across Kawich Range, 2½ miles north of Kawich 108
9. Section across north end of Reveille Valley, showing an inclosed valley partially underlain by basalt 114
10. East-west section across Reveille Range at northern boundary of area surveyed 117
11. East-west profile across Belted Range 3 miles north of Wheelbarrow Peak, showing nature, character, and present eastward tilt of Pliocene surface 119
12. East-west section across Belted Range through Belted Peak 126
13. North-south section through Oak Spring Butte, Belted Range 127
14. Second and third systems of quartz veins in granite at Trappmans Camp, as exposed on face of incline 138
15. Northwest-southeast section through Specter Range 149
16. Northwest-southeast section across Slate and Gold Mountain ridges 187
17. East-west section across Death Valley 6 miles north of boundary of area mapped 198

A GEOLOGIC RECONNAISSANCE IN SOUTHWESTERN NEVADA AND EASTERN CALIFORNIA.

By Sydney H. Ball.

INTRODUCTION.

FIELD WORK AND ACKNOWLEDGMENTS.

The field work on which this bulletin is based covered a period lasting from June to December, inclusive, 1905. The geologic work was under the general supervision of Mr. F. L. Ransome, and was carried on simultaneously with the mapping of the topographic base by Messrs. R. H. Chapman and B. D. Stewart.

The writer is fully conscious of the many inaccuracies of the geologic map herewith presented, but trusts that it may prove not only an aid to the prospector and miner, but a contribution to the geology of an intensely interesting region. Each day approximately 45 square miles was mapped in an area of by no means simple geology, and in many localities the geologic mapping of necessity preceded the topographic. No other region in the United States is so favorable to rapid mapping, since the exposures are unexcelled and the scant vegetation masks scarcely a geologic detail. The geology of the Paleozoic rocks is, however, difficult, partly on account of the lithologic similarity of many of the formations, but largely because these older rocks are in part hidden by mantles of Tertiary lavas and Recent gravels. In the text it has been the endeavor to distinguish clearly between observations made at close range and inferences drawn with the aid of the field glass. The mapping of the outer Goldfield hills and of the Pahute Mesa are particularly unsatisfactory.

To Mr. F. L. Ransome the writer desires to express his appreciation for general oversight and helpful criticism. Messrs. J. E. Spurr, F. B. Weeks, W. H. Emmons, and G. H. Garrey have been freely consulted on various points of Nevada geology. Messrs. R. H. Chapman and B. D. Stewart and their assistants, Messrs. T. C. Spaulding, E. A. Childers, and S. G. Benedict, aided the work by collecting in the field specimens of rocks from many points not visited by the writer. Mr. Spaulding also furnished some photographs and determined the species of the desert flora. To Messrs. W. F. Hillebrand, George Steiger, and Waldemar T. Schaller the writer is indebted for mineralogical determinations, and to Messrs. E. O. Ulrich, G. H. Girty, Edward M. Kindle, and F. H. Knowlton for paleontologic data. The helpful interest and kindly hospitality of the Nevada pioneers is also gratefully acknowledged.

LOCATION AND AREA.

The area surveyed (see fig. 1) is situated in the south-central portion of the Great Basin and includes portions of Esmeralda and Nye counties, Nev., and Inyo County, Cal. The topographic map is on a scale of 1:253,440 (approximately 4 miles to the inch), with contour intervals of 100 feet, and covers the area lying between 36° 30′ and 38° north latitude, and 116° 00′ and 117° 30′ west longitude. This area, embracing within its limits 8,550 square miles, is the equivalent of nine of the usual 30-minute quadrangles of the Geologic Atlas of the United States.

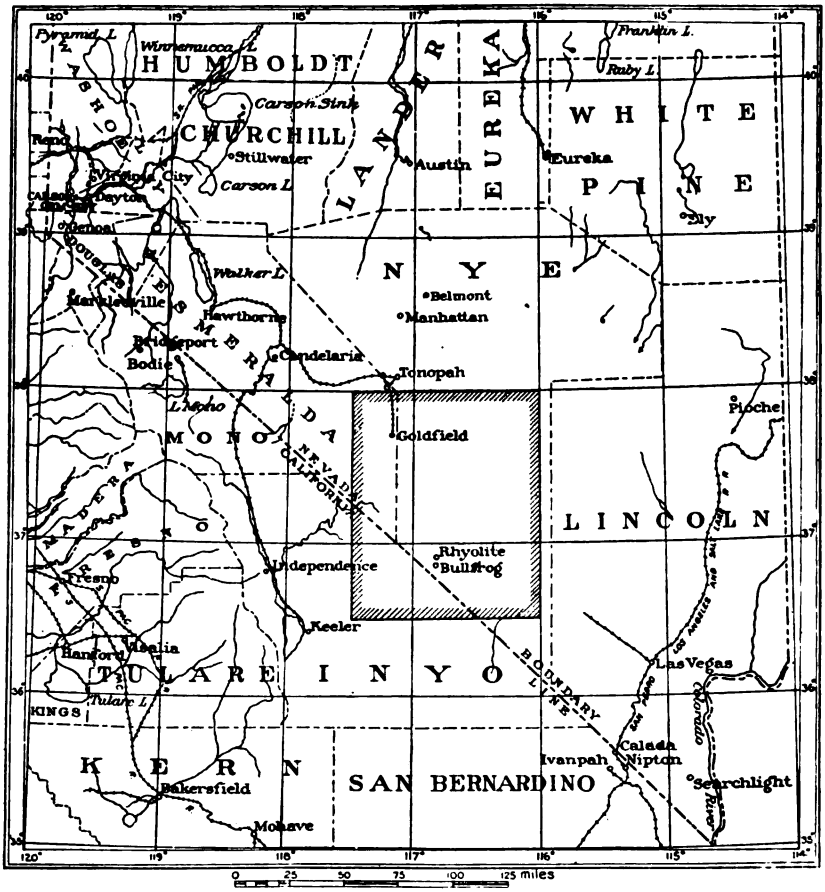

FIG. 1.—Index map showing location of area in southwestern Nevada and eastern California.

LITERATURE.

The literature dealing with this portion of Nevada and California is scanty. In 1871 Mr. G. K. Gilbert visited the Reveille Range and later the Oasis Valley and crossed the Grapevine Range. In 1899 Mr. J. E. Spurr went from Lida to Stonewall Spring and thence across the Cactus, Kawich, and Reveille ranges. He also crossed Death Valley and the Funeral and Panamint ranges to the south of the area included in the present map. Since that time he has made extended studies in the neighboring districts of Tonopah and Silver Peak. In 1899–1900 Mr. H. W. Turner surveyed geologically the Silver Peak area, a thirty-minute quadrangle, which adjoins on the northwest the area mapped in this report. In 1900 Mr. M. R. Campbell made a reconnaissance to the south of the area here described. In 1905 Messrs. F. L. Ransome, G. H. Garrey, and W. H. Emmons made detailed studies of the geology and ore deposits of Goldfield and Bullfrog, and a preliminary account of the results of their work appears in Bulletin No. 303 of the United States Geological Survey. Since the discovery of the veins of Tonopah in 1900 the technical journals have contained numerous references to the mines in this portion of Nevada and California, but these have not been included in the following bibliography, since, with a few exceptions, they contain nothing of permanent value:

Gilbert, G. K. Report on the geology of portions of Nevada, Utah, California, and Arizona examined in the years 1871 and 1872. U. S. Geog. and Geol. Surveys West of the One Hundredth Meridian, vol. 3, Geology, 1875, pp. 21–187.

Describes the Reveille and Amargosa (Grapevine) ranges and Bare Mountain, also the structure of the Basin Range.

Hague, Arnold. Geology of the Eureka district, Nevada, with an atlas. Mon. U. S. Geol. Survey, vol. 20, 1892.

Describes the geology and ore deposits of Eureka, Nev. The Paleozoic section will be used as the type section in the present report.

Spurr, J. E. Descriptive geology of Nevada south of the fortieth parallel and adjacent portions of California. Bull. U. S. Geol. Survey No. 208, 1903.

Describes the geology and contains a general geologic map, scale 15 miles to the inch.

Turner, H. W. Silver Peak folio; unpublished.

Describes general and economic geology of Silver Peak (Nev.) quadrangle.

Spurr, J. E. The succession and relation of lavas of the Great Basin region. Jour. Geol., vol. 8, 1900, pp. 621–646.

Spurr, J. E. Origin and structure of the Basin Ranges. Bull. Geol. Soc. America, vol. 12, 1901, pp. 217–270.

Campbell, M. R. Reconnaissance of the borax deposits of Death Valley and Mohave Desert. Bull. U. S. Geol. Survey No. 200, 1902.

Treats particularly of the borax deposits and of Tertiary lake beds.

Spurr, J. E. Geology of the Tonopah mining district, Nevada. Prof. Paper U. S. Geol. Survey No. 42, 1905.

Spurr, J. E. The ore deposits of the Silver Peak (Nevada) quadrangle. Prof. Paper U. S. Geol. Survey No. 55, 1906.

Ball, Sydney H. Notes on the ore deposits of southwestern Nevada and eastern California. Bull. U. S. Geol. Survey No. 285, 1906, pp. 53–73.

Ransome, F. L. A preliminary account of Goldfield, Bullfrog, and other mining districts in southern Nevada; with notes on the Manhattan district by W. H. Emmons and G. H. Garrey. Bull. U. S. Geol. Survey No. 303, 1906.

THE GREAT BASIN.

The Great Basin is an elevated region in Nevada and contiguous portions of Oregon, California, and Utah, containing approximately 208,500 square miles. None of its streams flow to the ocean, and in this it differs from all other provinces of the United States. The region is arid, the precipitation being less than 20 inches a year. The scenery, were it not for the grotesque form and bizarre coloring of many of the mountains and hills, would be depressingly dreary.

The mountain ranges of the region for the most part trend north and south and are characteristically rugged and bare, although the crests of some of the higher ranges are covered by a scant growth of timber. The mountains are cut by deep canyons, and in a few of these streams flow, only to sink in the desert gravels. Associated with the ranges are low hill groups and mesas, many of which also have a north and south elongation. Between the mountains and hills are broad, gently sloping, inclosed valleys, which send branches into and in places across the mountains. The lowest portion of most of the valleys is occupied by either a lake or a playa, which during the greater part of the year is a level waste of hard clay, but after heavy rains is covered by a thin sheet of water.

TOPOGRAPHY.

The area under discussion, a typical portion of the Great Basin, is one of mountain ranges and mesas with wide valleys of gentle slope between. To the north of the broad Pahute Mesa lie mountain ranges with a general north-south trend. Southeast of the mesa the mountains are small groups whose crest lines run in various directions. The Grapevine and Panamint ranges, southwest of the mesa, extend from northwest to southeast and are in consequence parallel to the Sierra Nevada. The relief of the area is great; Kawich Peak is 9,500 feet above sea level and the part of Death Valley within the area lies 280 feet below sea level. Few of the ranges, however, rise more than 3,000 feet above the flat valley, although the mountain front on either side of Death Valley reaches an elevation of 7,000 feet within a distance of 12 miles. Between mountains with distinct crests, such as the Kawich Range, and the small hillocks in the desert valleys there is every gradation. The mountains are cut by gorges which in the more elevated ranges are deep canyons. The streams descend from the mountains to the flat valleys on alluvial fans and commonly even the stream channel disappears before the playa in the center of the valley is reached.

The valleys are inclosed basins which slope rather steeply next to the mountains, but decrease in grade rapidly, the central portion being a flat in which the eye can see no differences in relief. This level bottom is in most cases a playa. The borders of any given valley are, as a rule, approximately equal in elevation, although the desert gravels extend to greater elevations on the higher inclosing mountains. In such cases, while the slopes are of approximately equal descent, that from the higher mountains is much longer, and in consequence the playa is nearer the lower hills. Near the mountains the alluvial slopes are scored by numerous drainage lines, and hills protrude through their surface. The inclosed basins send bays and arms of detrital wash into the mountains and in places two opposed arms meet and form a strait of alluvial material. Every hill within the area furnishes each year material with which it is slowly being overridden by the constantly growing flat valleys. These valleys at one time may have been united to one another so that they formed a single drainage system, flowing to the south. Whether this was the case or not, it is evident that they are formed in three ways—by the union across a valley of opposed alluvial fans, as is exemplified by the small inclosed valleys of Grapevine Canyon; by the outflow of a lava barrier, such as that between Sarcobatus Flat and the inclosed valley to the north; or by orogenic movements, of which the Bullfrog Hills between Sarcobatus Flat and the Amargosa Desert are, in part at least, an example.

CLIMATE.

The area has an arid climate, with hot, dry summers and, except in the higher mountains, mild winters. The temperature in summer often rises above 100° F., the intensity of the heat, however, being mollified by the dryness of the atmosphere. Records kept at Hawthorne, Sodaville, and Palmetto, Nev., and quoted by Turner[a] show that the average annual precipitation to the north of the area varies from 3½ inches in the valleys to 15 inches on the highest mountains. These figures are probably both somewhat high for the area under consideration. The precipitation is largely concentrated in cloudbursts and 4 or 5 inches of rain may pour down in a few hours.

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[a] Turner, H. W., Silver Peak folio; unpublished.

HYDROLOGY.

GENERAL STATEMENT.

The water resources of this area consist of streams, springs, tanks, wells, and snow. Data concerning the local water resources are given in the descriptions of the mountain ranges and valleys. While sufficient water is available or can be developed at a number of points for villages, mills, small ranches, and truck gardening, it is probable that the present supply of the area will never be greatly increased.

STREAMS.

Well-developed drainage systems exist in the hills and mountains, but nearly all the channels, except in times of cloud-bursts, are dry. Only in the higher mountains where heavy snows fall are perennial streams found, and the longest of these has a length of less than 4 miles. While the streams are small, a few, notably the Amargosa, furnish sufficient water for concentrating mills.

The so-called Amargosa River heads well up in Pahute Mesa, and the stream channel can be traced through the Amargosa Desert into Death Valley. Water comes to the surface only in that portion known as Oasis Valley, where numerous springs burst forth and give rise to small streams from 200 feet to one-half mile in length. Above Indian Camp the channel of the Amargosa occupies a canyon 500 feet deep, while between this point and Beatty the valley, from 200 yards to 1 mile wide, is bordered by low hills. The valley floor is here formed of fine clay, which, where not covered by drifting sand, supports a fair growth of salt grass. In places many acres are covered with an incrustation of white alkali. Between Beatty and Gold Center the valley contracts to a gorge. In the Amargosa Desert the channel is from 4 to 15 feet deep and 100 feet wide. In addition to the recent channel there are several older channel remnants. This shallow, sinuous channel, lined by heaps of angular bowlders and banks of sand, strongly resembles the deserted river beds of the Great Plains.

Four small streams are situated in Kawich Range. Breen Creek has its origin in a large number of springs rising from a marshy area on the Breen ranch. The stream in summer is from 1 to 3 feet wide and 2 to 4 inches deep. Early in the morning it flows to Silverbow, a distance of 3½ miles, but by night the lower 2 miles are dry. The water at sunset is warm, while in the morning it is cold. The daily variation in size and temperature is characteristic of all the streams of this region and is due to the great heat of midday, which warms the water and induces evaporation. The large spring 1¼ miles below the Longstreet ranch yields a stream of water 1 foot wide and 3 or 4 inches deep, which sinks in the valley gravel one-half mile from its source. The underflow rises to the surface three times in the course of the tortuous Little Mill Creek Canyon, on the east side of the Kawich Range above Eden. The largest of these streams is 1½ feet wide and flows 1½ miles. A streamlet 200 yards long flows from the large spring commonly called "Georges Water," on the east side of the Kawich Range.

Salt Creek, 15 feet wide, rises in Death Valley, flows 2 miles, and then sinks. The water is heavily charged with sodium chloride and other salts. In the Salt Flat of Death Valley are many gently flowing small streams and pools of salt water. Small streams flow from the Staininger ranch and from Grapevine Springs, in the Amargosa Range, but each sinks within 1 mile of its head. Cottonwood Creek, in the Panamint Range, is 4 feet wide at its spring head, but sinks in gravel within 2 miles. Cottonwood and willow trees and grapevines line its banks, and water cress grows luxuriantly in the water. A short distance below the sink of this stream water again runs in the canyon for 100 yards. In the Stonewall Mountains water rises in the bed of a gulch one-fourth mile north of Stonewall Spring. The streamlet, 1 foot wide and 3 inches deep, sinks in the gravel 100 feet from its source.

SPRINGS.

The springs are of two kinds—hot or warm and cold. The hot springs appear to be vents of deeply circulating waters; the cold springs evidently come from shallow depths.

HOT OR WARM SPRINGS.

Alkali Spring is located 11 miles northwest of Goldfield. The waters originally rose at a number of small seeps, but recently the Combination Mines Company, of Goldfield, drove a tunnel into the gentle slope, concentrating the flow in a single channel. According to Mr. Edgar A. Collins, of this company, about 85,000 gallons of water per day flows from the spring and is pumped to the Combination mill at Goldfield. The water is clear, slightly alkaline in taste, and smells of hydrogen sulphide. An analysis by Abbot A. Hanks, kindly furnished by Mr. Collins, is as follows:

Analysis of water from Alkali Spring.

	Grains per wine gallon.
Silica, insoluble	2.449
Iron oxides and alumina	.314
Calcium carbonate	6.764
Sodium chloride	6.122
Sodium sulphate	43.341
	58.990

At the mouth of the 40-foot tunnel the temperature of the water is about 120° F., and at the breast it is at least 140° F. The stream flows from residual bowlders and soil of the later rhyolite, and the bowlders are badly decomposed and crumble readily in the hand. One hundred yards north of the pumping station is a low dome of grayish-brown travertine, probably an abandoned vent of the spring.

Hicks Hot Springs, situated at the base of a low hill of silicified rhyolite on the east bank of Amargosa River about 7 miles above Beatty, are five in number. The hottest spring, which supplies the bath house, is said to have a temperature of 110° F. and to furnish 65,000 gallons per day. The springs in the vicinity which flow from the gravels of Oasis Valley are cool, and it is possible that the warm waters are genetically connected with the silicification of the rhyolite.

Water rises at the Staininger ranch, in the Amargosa Range, at several places in the canyon gravel, the total flow approximating 600,000 gallons a day. The water in December had a temperature of 75° F., while that of the air was but 49°. The surrounding hills are formed of Siebert lake beds and Pliocene-Pleistocene basalt flows. The Grapevine Springs flow from shallow depressions and valleys in the older alluvium and from the contact of that formation and the Pogonip limestone. Much of this water is tepid. Pliocene-Pleistocene basalt flows occur in this vicinity. At Ash Meadows, in the Amargosa Desert, 1 mile south of the area mapped, springs are associated with the older alluvium. The temperature of the larger springs is reported to be 76° F.; that of one of the smaller springs is 94° F.

These hot or warm springs are characterized by a rather large and constant flow of water. They are without much doubt the vents of deeply circulating waters, and their association in many places with recent volcanic rocks suggests that they may in part owe their heat to volcanism, if, indeed, they are not magmatic waters.

COLD SPRINGS.

Cold springs and seeps are situated either at the contact of alluvial deposits and the mountain bed rock or in the gravels of mountain canyons. In the latter case the surface waters appear to seep through the valley gravel and to rise where the bed rock forms a bar across the channel. The spring from which Cottonwood Creek flows may be cited as an example. Springs of this class are common in the large quartz-monzonite area of the Panamint Range. In the granite of Gold Mountain and the Cambrian rocks of the Montezuma district a water zone occurs at the contact of the solid rock and the residual and detrital soil. In other cases surface water has seeped into the more pervious strata, particularly the Siebert lake beds, the older alluvium, and altered varieties of rhyolite, and many springs are situated where these beds either outcrop or are covered by a veneer of detrital or residual material. Springs are located sporadically throughout the area surveyed, but seem to be more abundant around the bases of the higher mountains, especially of those which are covered with forests.

The precipitation both in winter and summer is greater on such mountains, and forested areas retard the run-off and permit the water to sink into the rocks. The flow is subject to seasonal changes, and during August and September many springs are dry or greatly diminished. Heavy rains also cause fluctuations. The water is cool, sometimes even cold, and is usually palatable, though a few of the springs are slightly saline, and some contain other salts.

From the direct dependence of the flow of the cold springs on seasonal rotation and on unusually heavy rains it is evident that these springs are in greater part, at least, the vents of shallow circulating waters.

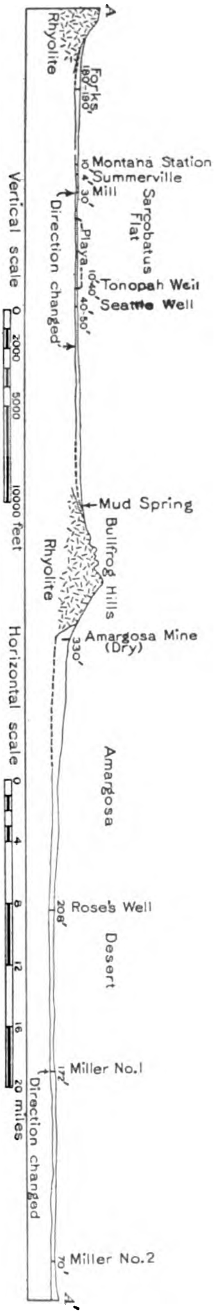

FIG. 2.—Profile across Sarcobatus Flat and Amargosa Desert, showing relation of ground-water level to surface.

TANKS.

Tanks are natural depressions in an impervious stratum, in which rain or snow water collects and is preserved the greater portion of the year. In the area studied the principal formations upon which tanks occur are the playa clay and the more compact layers of the basalt. The water in tanks decreases in volume and becomes poorer in quality as summer progresses; by August some are dry, and the water of others is scarcely drinkable.

WELLS.

Wells have been sunk at a number of places in the gravels of either the flats or the gulches. Wells sunk in gulches where there are signs of water have almost without exception proved successful; wells in the flats have been almost as uniformly successful. In the inclosed valleys the water table near the mountains, where the desert gravels are very permeable to water, seems to lie at considerable depths below the surface, but at the playas the two planes approach each other. In Death Valley water stands upon the surface, while in Sarcobatus Flat the water table is but 2 feet below the surface (fig. 2). In other flats the depth is considerably greater, but by analogy wells located near playas should encounter water at less depths than those on alluvial slopes. The supply seems sufficient for stock, but insufficient for extensive irrigation.

The prospect of developing flowing wells in the area is slight. The Paleozoic rocks and the Tertiary volcanics are too much faulted to present extensive and continuous water-bearing strata. In the flat valleys beds of sand and gravel and layers of clay may be locally so superimposed upon one another as to furnish artesian conditions. Flowing wells, however, would be encountered only by the merest chance and would probably be weak.

In Turkestan and in the arid regions of southern California gently ascending tunnels have been driven into alluvial fans and water so obtained has been used for irrigation. The construction and maintenance of such tunnels are expensive, and in the area studied they would meet with success in few if any of the larger fans in which strong springs sink.

SNOW.

During the winter snow lies on many of the higher ranges and forms a valuable water supply to the prospector and traveler.

SIGNS OF WATER.

For the benefit of those unused to desert conditions it will perhaps be of value to describe the signs which indicate the presence of water in southwestern Nevada. Vegetation near springs or tanks is noticeably luxuriant, and in consequence patches of vivid green are worthy of investigation. The desert shrubbery attains an unusual size around springs, and a number of bushes and flowers not elsewhere seen are abundant. The willow, wild rose, elderberry, and gooseberry, the red honeysuckle and the poppy, and the " water bush," or tonopah of the Indians, are unknown except in the vicinity of water. The " water bush " is a shrub 2 to 3 feet high, with grayish-green leaves set on a white stalk thickly covered with spikes 1 inch long. Mesquite grows in Death Valley and the Amargosa Desert, and water may usually be obtained at slight depths near its roots. Where rye grass and the cane grow there is water at the surface or at moderate depths.

Rabbits, coyotes, and birds are particularly abundant near water. Mourning doves at sunset often flock around water holes. It is more than unfortunate that in the last two years the shotgun and trap have greatly diminished the numbers of this bird, one of the surest of water guides. Stock trails usually lead to water, and the point at which several trails converge is in most cases a spring. Since the animals go directly to water from the flats and on leaving the spring spread over the surrounding country as they feed, the trail becomes perceptibly plainer as it nears the spring. Many such trails, however, are winter trails, and in consequence the recency of tracks should be noted in searching for water.

Wagon roads and trails are constructed from one spring or tank to another and unwatered stretches of more than 40 miles are uncommon. The Indians, except when gathering piñon nuts, camp at water, and old Indian camping grounds, numerous fragments of stone implements, smoke-stained rocks, and carvings on rock may be valuable water indicators. Perhaps the best water signs are stone monuments built by the Indians and early white explorers either on high points on each side of the trail at water or close together on a commanding point above the water. These monuments are from 2 to 8 feet in height and resemble mineral monuments, except that they bear no location notices. From some of them flat stones set on edge point toward the water; at others a sharpened stick lying in a forked one is the indicator.

ANIMAL LIFE.

Animals are nowhere abundant in the area under consideration, and Death Valley appears to be without resident animals, with the exception of a few coyotes. The lack of food and the scarcity of water render the area as a whole unfit for large animals. Bands of wild horses roam the lowlands around the Cactus and Kawich ranges, however, and a few antelope feed in the valleys on either side of the Kawich Range and on Pahute Mesa. Mountain sheep are reported from the Lone Mountain country and old trails were noted on the higher peaks of the Stonewall Mountains. A few mountain sheep still live in the Panamint Range and in the south end of the Amargosa Mountains. Coyotes and rabbits are often seen, particularly in the vicinity of springs. Animals allied to gophers seem less dependent on known water holes.

Hawks, ravens, magpies, sparrows, and owls fly long distances from water. Mourning doves, on the other hand, flock around the springs and a few coveys of California quail live in the better watered portions of the Panamint and Amargosa ranges. Ducks in their annual migrations stop to rest and feed at the springs in the Oasis Valley and at Ash Meadows and the Furnace Creek ranch.

Various species of lizards, including the horned toad, are common in the valleys. Rattlesnakes, both the ordinary variety and the peculiar sidewinder, are sometimes seen, but are by no means as common as report would lead one to believe. The same is true of the scorpion and tarantula. Ants are common, and brilliantly colored butterflies are unexpectedly numerous. Mosquitoes and similar pests occur only near a few of the larger water holes.

VEGETATION.

Open forests of piñon (*Pinus monophylla*) and juniper (*Juniper utahensis*) occur above the dry timber line,[a] which approximates an elevation of 6,500 feet. The wood of both trees, particularly the piñon, is good fuel. Only exceptionally are the trunks large enough for mining timbers other than lagging. The cones of the piñon incase delicious nuts, which are carefully gathered by the Indians for winter food. The vividly green mountain mahogany (*Cerocarpus ledifolius*) is associated with these trees on the highest peaks.

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[a] Russell, I. C., Bull. Geol. Soc. America, vol. 14, 1904, pp. 556–557.

The most striking plant of the area is the yucca (*Yucca arborescens*), commonly called the "Joshua tree." It grows in open groves on the upper alluvial slopes and the lower lava mesas. Stiff spiny leaves are thickly set on the peculiarly branching stalk, which reaches a maximum height of 30 feet. Associated with the yucca are various species of cacti, including the prickly pear, the barrel cactus, and several branching forms. The sagebrush is widely distributed in the mountains, while the "creosote brush" (*Larrea tridentata*) and related shrubs occupy the lower alluvial slopes. In April and May the red geranium, the yellow dandelion, the purple horsemint, and the white primrose enliven the monotonous greenish gray of the desert shrubbery.

Grateful spots of green mark the springs. Here the gooseberry, wild rose, poppy, honeysuckle, wild rye grass, and cane thrive, while willow bushes and oak shrubs grow in thickets around some of the springs. At Poison Spring, in the Amargosa Range, the rocks are covered by the dainty maidenhair fern. In Cottonwood Canyon and at the ranches in Oasis Valley willow and cottonwood trees grow to a height of 40 feet.

Sufficient grass for scant forage grows on the upper alluvial slopes and in some valleys in the mountains. Burros will live almost anywhere in the area, but horses do poorly on the best of feed. The most nutritious grass grows in small bunches and is commonly called "sand grass." The sun's heat cures it in summer and in consequence a scant supply is available throughout the year. The grass around the springs, usually called "salt grass" (*Distichlis spirata*), is of little value to work horses. The white sage (*Eurotia lanata*) grows in the southern half of the area. Sheep are said to thrive on it and horses eat it with apparent relish.

CULTURE.

INDUSTRIES.

Prospecting and mining are practically the only industries, and nearly every person within the area surveyed is dependent directly or indirectly on these pursuits. The miners are segregated in the towns and camps; the prospectors range from one group of hills to another. At the Longstreet and Breen ranches in the Kawich Range, the Staininger and Indian ranches in the Armagosa Range, and at several of the springs in Oasis Valley small acreages are irrigated and hay, melons, potatoes, and other farm products are raised. The finer detrital material of the valleys is an excellent soil, but water for irrigation is lacking. A few cattle pasture in the Kawich Range, and while small herds might possibly live at other localities, the beef required by the mining camps will for the most part be shipped in by rail or driven across from California.

TOWNS.

The towns of this desert mining territory typify both the push and energy of the western pioneer and the unstable conditions of new gold fields. With the report of a rich discovery a town of 100 tents rises in a day, only to disappear almost as rapidly if the new find falls short of expectations. The population of all the towns fluctuates greatly.

Tonopah, with a population of about 8,000, lies 4 miles north of the area and is the county seat of Nye County, Nev. It has a number of prosperous mines and is the shipping point for some of the northern and northeastern mining camps of the area under discussion. Tonopah is the terminus of a railroad and has electric light, city water, telephones, newspapers, both daily and weekly, banks, churches, and schools.

Goldfield, with a population of about 9,000, has valuable gold mines and is the present terminus of the Tonopah and Goldfield Railroad. Like Tonopah, it has most of the essentials of city life, and the number of substantial buildings is surprising in consideration of the fact that the first tent was pitched here in January, 1904. Columbia, a rival town, adjoins Goldfield and has its own post-office. Goldfield and Columbia are supply points for the prospectors and miners in the central portion of the territory here described.

Rhyolite, Bullfrog, and Beatty are rival towns of the Bullfrog mining district. Rhyolite and Bullfrog, whose main streets meet, have a total population of approximately 2,500. Each has its own post-office, water system, and newspapers, and the two have common telegraph and telephone systems. The towns were founded in January, 1905, and already contain a number of substantial stone, wood, and adobe buildings. Beatty, 4 miles east of Rhyolite, is situated on Amargosa River and has a population of 700. It has about the same improvements as Bullfrog and Rhyolite. These three towns are the supply points for the southern portion of the area. Gold Center, a tent town of 40 inhabitants, is situated 2 miles below Beatty, on Amargosa River.

Silverbow, on the east side of the Kawich Range, has a post-office and a weekly newspaper. Kawich is a mining camp and post-office on the west side of the Kawich Range. The number of inhabitants fluctuates and has varied from 50 to 400. Lida is a mining camp of the seventies revived. At present it has a population of 200. Thorp, more commonly known as Montana Station, is a post-office and stage station. Travelers can find accommodations for man and beast at

Ramsey Well, Klondike Well, Cactus Spring, Tokop, Cuprite, Currie Well, Miller Well No. 1, and Ash Meadows.

RAILROADS AND STAGES.

The Tonopah and Goldfield Railroad is a broad-gage line, connecting with the Union Pacific Railroad at Hazen, Nev. The Carson and Colorado Railroad in Owens Valley is from 25 to 45 miles west of the western border of the area. The San Pedro, Los Angeles and Salt Lake Railroad, commonly called the Clark road, is from 40 to 75 miles east of the area. A railroad has been surveyed from Goldfield to Bullfrog and two branches are projected from the Clark road to the same point. The position of the railroads is shown on the sketch map (fig. 1). A daily stage runs from Goldfield and another from Las Vegas to the towns of the Bullfrog district. The trip from Goldfield takes about fourteen hours, from Las Vegas thirty-two hours. Daily or semidaily automobiles make the run from Goldfield to Bullfrog in four to six hours. Lida and Goldfield, Kawich and Tonopah, and Silverbow and Tonopah are connected by daily stages.

ROADS AND TRAILS.

Good roads and trails cross the area in all directions and few countries so sparsely populated are so accessible. The road gradient is low, although in the mountains short stretches are steep. Teaming is heavy in the sand surrounding the playas and in some of the stream gravels. Roads on playa clays are smooth and hard except after heavy rains, when wagons sink hub deep in the sticky clay. Roads and trails are shown on the geologic map (Pl. I). Few places are impassable to a pack train, and a wagon can go anywhere in the lower hills and mountains.

STRATIGRAPHIC GEOLOGY.

It is proposed in this section to describe briefly the formations of southwestern Nevada and eastern California (fig. 3) and to outline the general distribution of each. They are described in detail under each geographic subdivision in the section on descriptive geology. It will be convenient to take the formations up in order, from the oldest to the youngest, irrespective of their sedimentary or igneous origin. Owing to the lack of continuity and the complex structure of the Paleozoic rocks, their description is less accurate than that of the younger formations. The stratigraphic units of the Eureka[a] (Nev.) section are used as type formations for the Paleozoic rocks.

PRE-CAMBRIAN.

The presence of pre-Cambrian rocks was not definitely determined. The Prospect Mountain quartzite (Lower Cambrian) of the Specter

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[a] Hague, Arnold, Mon. U. S. Geol. Survey, vol. 20, 1892, p. 13.

Range contains pebbles of quartzite, jasperoid, and vein or pegmatitic uartz derived from pre-Cambrian formations. The mica schist of he Bullfrog Hills is pre-Ordovician, and although considered of Cambrian age, it may be pre-Cambrian. The schist at Trappmans Camp and the series in the south end of Amargosa and Panamint ranges are also probably Cambrian, although possibly pre-Cambrian.

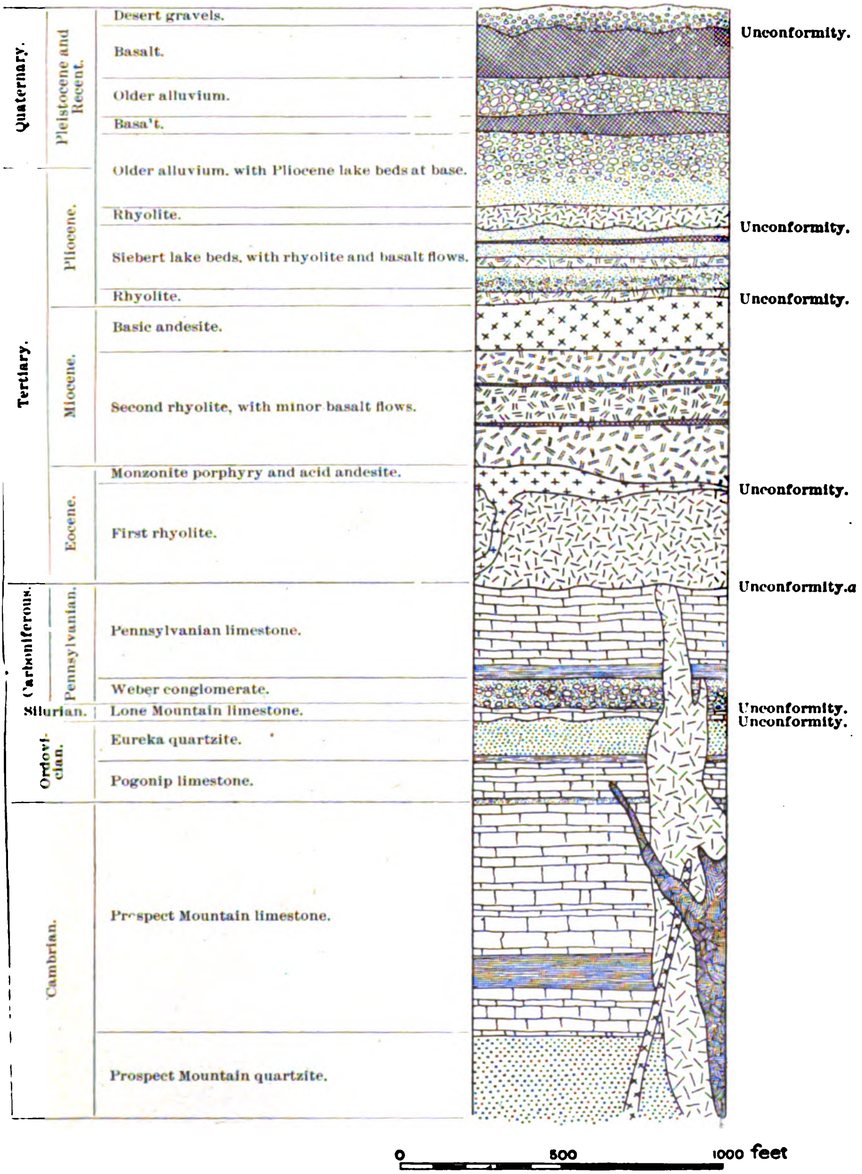

FIG. 3.—Columnar section of rocks of southwestern Nevada and eastern California.

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[a] Rocks below this are cut by granite, which in turn is cut by monzonite porphyry, and this in turn by diorite porphyry.

CAMBRIAN.

In the Specter Range from 2,000 to 3,000 feet of quartzite and conglomeratic quartzite conformably underlie limestone containing Cambrian fossils. The rather impure quartzite, which grades into minor beds of slaty shale, is probably the equivalent of the Prospect Mountain quartzite[a] described by Hague, from the Eureka district. Less certainly to be correlated with this formation is the quartzite with intercalated schist and marble beds of the Amargosa and Panamint ranges, a rock series which may possibly be of pre-Cambrian age.

Conformably overlying the Prospect Mountain quartzite in the Specter Range is a limestone apparently from 5,000 to 6,000 feet thick, which is probably to be correlated with the Prospect Mountain limestone[a] of Hague. The limestone is dark gray, compact, fine grained, and crystalline. Black chert occurs at certain horizons. In the Silver Peak Range, Stonewall Mountain, the Goldfield, Southern Klondike, Lone Mountain, and Mount Jackson hills, and Slate and Gold Mountain ridges occur rocks that are in part at least of Lower Cambrian age. The predominant member is a dense dark-gray limestone of finely crystalline texture. As a rule it is massively bedded. In a number of places this limestone has been silicified to a banded gray and black jasperoid. Interbedded with the limestone are layers of green slaty shale, usually finely laminated. In the Silver Peak Range and the Lone Mountain foothills the shale reaches a thickness of 1,000 feet. These rocks, in part at least, are the equivalent of the Prospect Mountain limestone, although lithologically rather distinct from that formation in the type locality.

Of less certain Cambrian age are the mica schists of the Bullfrog Hills, Tolicha Peak, and Trappmans Camp. The Secret Canyon shale and the Hamburg limestone[a] and shale were not recognized, and the Cambrian limestones appear to pass upward without distinct lithologic break into the Pogonip limestone.

ORDOVICIAN AND SILURIAN.

The Pogonip limestone as described by Hague[b] is 2,700 feet thick and contains Upper Cambrian fossils at its base and Ordovician fossils in its middle and upper portions. At Eureka it overlies the Hamburg shale[a] conformably, while in southwestern Nevada it seems to succeed the Cambrian limestone without marked lithologic change. The Pogonip limestone is well exposed in the Belted, Amargosa, and Panamint ranges and in Bare Mountain, while transitional beds between it and the Eureka quartzite occur in the Kawich Range and a small area of what is probably the Pogonip limestone is situated in the Cactus Range. The limestone is dark gray, fine to medium grained, and dense. It is distinguished from the Cambrian limestones, already described, by a somewhat lighter color, a slightly coarser and less crystalline texture, and rather more massive bedding. Near the center of the section, which ranges in thickness from 2,000 to 4,000 feet, is about 100 feet of white or pinkish quartzite. The transitional rocks from the Pogonip to the overlying Eureka quartzite are an interbedded series of limestone, shale, and quartzite.

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[a] Present usage of the Survey does not sanction the double use of formation names, as Prospect Mountain quartzite and Prospect Mountain limestone, but as this reconnaissance paper is not the place to propose new names, they are retained as used by Hague.

[b] Hague, Arnold, Mon. U. S. Geol. Survey, vol. 20, pp. 48–54.

The Eureka (Ordovician) quartzite described by Hague as overlying conformably and without transitional beds the Pogonip limestone was recognized on stratigraphic grounds in the Amargosa and Kawich ranges, in the Bullfrog Hills, and on Bare Mountain, while in the Cactus Range and the hills between it and the Kawich Range quartzite areas isolated in Tertiary or Recent rocks are considered its equivalent. The Eureka quartzite in southwestern Nevada is a typically white or pink, fine to medium grained, pure metamorphosed quartzose sediment. Some beds, however, are conglomeratic quartzites, while others are argillaceous and grade into thin, interbedded sheets of dark-colored slaty shale. It varies from the quartzite of Hague chiefly in two characteristics—first, its greater thickness, reaching 1,200 to 1,500 feet in the Kawich Range, and, second, in being underlain by interbedded quartzites, shales, and limestones, transitional beds from the Pogonip limestone.

Hague[a] gave to the uppermost division of the Ordovician and Silurian rocks at Eureka the name “Lone Mountain limestone.” This formation lies unconformably upon the Eureka quartzite and is 1,800 feet thick. It consists of black, gritty limestones at the base, which pass upward into light-gray, siliceous limestones. Its fossils include both Trenton and Niagara faunas. In the Amargosa and Kawich ranges and the Bullfrog Hills the Lone Mountain limestone is a gray, dense rock, of which about 400 feet is exposed.

DEVONIAN.

No Devonian formations were found in the course of the present work, and while such rocks may have been overlooked or may lie buried beneath Tertiary lavas it is tentatively believed that this portion of Nevada was a land mass during at least the greater part of Devonian time. The alternative hypothesis is that the Devonian beds were eroded away during post-Mississippian and pre-Pennsylvanian time, a period of important erosion in many portions of the West.

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[a] Hague, Arnold, Mon. U. S. Geol. Survey, vol. 20, 1892, pp. 57–59.

CARBONIFEROUS.

Hague[a] describes the Weber conglomerate at Eureka as consisting of 2,000 feet of coarse and fine conglomerate containing angular and rounded fragments of chert, interbedded with reddish-yellow sandstones, and lying conformably between the limestones of the lower and the upper "Coal Measures." In the Belted Range the Pennsylvanian limestone is underlain by 300 to 500 feet of shale, which in turn overlies 800 to 1,000 feet of sandstone. The shales are thin bedded and of green, gray, or brown color. The sandstone is in part a rather pure quartzose rock and in part an arkose. Interbedded conglomerates contain well-rounded pebbles of limestone, quartzite, flint, and jasperoid, evidently derived from early Paleozoic rocks. Lithologically similar beds occur in the Cactus Range. These rocks are probably the equivalent of the Weber conglomerate at Eureka.

Pennsylvanian limestone also occurs in the Panamint and Reveille ranges and forms a small area on Shoshone Mountain. This limestone is dense, dark gray or black, and fine to medium grained. Specimens from many beds emit a fetid odor when hit with the hammer. Nodules of black flint are characteristic at many horizons. The limestone in the Belted Range, 2,500 feet thick, has near its center 55 feet of limestone conglomerate.

POST-JURASSIC AND PRE-TERTIARY IGNEOUS ROCKS.

The granite and associated rocks of the Belted and Panamint ranges, of Pahute Mesa, and of the Gold Mountain ridge contain fragments of gray, fine-grained monzonite and quartz-monzonite porphyry. These fragments, while clearly somewhat older than the rocks in which they occur, are massive and possibly represent an earlier solidification of the magma, from which the granitic rocks were afterwards differentiated. These rocks include types ranging on the one hand from alaskite through muscovite, muscovite-biotite, and biotite granites to a quartz monzonite approaching granodiorite, and on the other hand from a soda-rich granite to soda syenite. While the granitoid rocks in the areas shown on the map are of rather constant composition, transitions occur in a single area. In the Gold Mountain ridge, for example, of two ledges separated by less than 10 feet, one is a microcline-granite porphyry and the other a hornblende-bearing quartz-monzonite porphyry. Porphyritic types of the granitoid rocks occur, as well as aplites and pegmatites, later differentiations of the same magma.

These granitoid rocks are widely distributed over the region under consideration, although they cover larger areas in the western portion.

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[a] Hague, Arnold, Mon. U. S. Geol. Survey, vol. 20, 1892, pp. 91–92.

Similar rocks are the predominant formation from longitude 117° 30′, the border of the region, westward to the Sierra Nevada.[a]

From the uniform amount of mashing which these rocks have suffered it is evident that all are approximately of the same age. They intrude the Paleozoic rocks where the two are in contact, and fragments of them are included in Tertiary lavas. The youngest of the Paleozoic rocks is of Pennsylvanian age and the earliest lava is probably Eocene; in consequence the granites are of post-Carboniferous and pre-Eocene age. It is shown in the section on geologic history (p. 39) that the close folding of the Paleozoic rocks occurred in post-Jurassic time and the granite intrusion is believed to have been a relatively late event in this period of deformation, an inference supported by the comparatively unmashed condition of the granites. Their post-Jurassic age is thus probable, a conclusion in accord with that of Spurr for the granites of Silver Peak[b] and Goldfield[c] and that of Louderback[d] for those of the Humbolt region. This would make these granitoid rocks essentially contemporaneous with the granodiorite of the Sierra Nevada.

Dikes and sheets of a ferromagnesian-poor quartz-monzonite porphyry intrude Paleozoic sedimentary rocks and granite of the Silver Peak and Panamint ranges and of Slate Ridge. This rock near Lida is apparently cut by the diorite porphyry described in the next paragraph. It is presumably a second intrusion of the granitic magma.

Dikes of diorite porphyry and fewer intrusive masses of diorite occur in the Silver Peak, Panamint, Amargosa, and Cactus ranges, the Gold Mountain and Slate ridges, and the Bullfrog, Mount Jackson, and Lone Mountain hills. These rocks typically contain brown hornblende. They are younger than the Paleozoic rocks and the igneous rocks already described and nowhere were they observed cutting Tertiary lavas. Pebbles of diorite porphyry occur in the Siebert lake beds (Miocene) and the rock is probably of post-Jurassic and pre-Tertiary age. Its intrusion was the last event in the pre-Tertiary igneous activity.

TERTIARY.

The Tertiary rocks include a number of igneous rocks, lava flows and fewer intrusive masses, and sediments laid down in lakes. The accompanying table presents correlations of the Tertiary rocks of the various ranges

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[a] Spurr, J. E., Bull. U. S. Geol. Survey No. 208, 1903, Pl. I.

[b] Spurr, J. E., Bimonthly Bull. Am. Inst. Min. Eng., 1905, No. 5, p. 955.

[c] Spurr, J. E., Bull. U. S.. Geol. Survey No. 260, 1905, p. 133.

[d] Louderback, G. D., Bull. Geol. Soc. America, vol. 15, 1904, p. 336.

The oldest of the Tertiary rocks is a rhyolite which occurs in Stonewall Mountain. This occupies a similar stratigraphic position with rhyolites in the Panamint Range, in the Randsburg district, and near Daggett in the Mohave Desert, which, according to Spurr,[a] lie beneath "lake beds which are probably, in part at least, Upper Eocene." This rhyolite in Stonewall Mountain is cut by dikes of quartz-monzonite porphyry and quartz syenite, which are probably contemporaneous with monzonite porphyry, quartz-monzonite porphyry, hornblende-biotite latite, and biotite andesite of other ranges. These rocks are in part intrusive masses and in part flows. Prior to the succeeding extrusion of rhyolite these rocks of siliceous andesitic and monzonitic composition were eroded, unconformities being observed in the Kawich, Amargosa, and Cactus ranges, in the Bullfrog Hills, and in Shoshone and Skull mountains. Then followed an extrusion of rhyolite, with minor siliceous latites and dacites, which was attended by insignificant basalt flows. This period of extrusion of rhyolitic lavas, the most important in this portion of the Great Basin, was not, however, strictly contemporaneous over the whole area; it is believed, for example, that the earlier rhyolite of Goldfield represents only the base of the rhyolite series of the Bullfrog Hills, and that the upper portions of the Bullfrog mass may have been extravasated while the andesites and dacites of Goldfield were solidifying. This rhyolite is everywhere separated from the Siebert lake beds by a marked erosional unconformity, and in the Kawich and possibly in the Cactus Range it is separated by an erosional unconformity from the succeeding andesites. The next younger igneous rocks, which are confined to the northern half of the area mapped, are basic andesites and dacites. These two rocks were found in contact only in the area covered by the Goldfield special map, and here Mr. F. L. Ransome[b] found the dacites intrusive into the andesites. The succeeding igneous rocks are rhyolites and siliceous latites and dacites which occur only in the Goldfield and Southern Klondike hills and the Silver Peak Range. In the latter two localities at least these rocks are interbedded with the Siebert lake beds without erosional unconformity.

Thick masses of sediments occur in the majority of the ranges of the area, and on lithologic and stratigraphic grounds are correlated with the Siebert lake beds of Miocene age at Tonopah described by Spurr.[c] These tuffaceous sandstones and conglomerates, largely composed of rhyolitic material, reach an observed maximum thickness (in the Amargosa Range) of 1,150 feet.

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[a] Spurr, J. E., Jour. Geol., vol. 8, 1900, p. 633.

[b] Oral communication.

[c] Spurr, J. E., Prof. Paper U. S. Geol. Survey No. 42, 1905, pp. 51–55, 69–70.

Correlations of Tertiary formations in various ranges.

[Symbol × shows presence of formation.]

Range.	Eocene or earlier.			Miocene.								Pliocene.			Pleistocene in part.	
	Rhyolite.	Monzonite and biotite andesite.		Rhyolite, dacite, and latite.	Basalt, contemporaneous with rhyolite of preceding column.		Andesite and dacite.	Rhyolite and biotite latite.	Siebert lake beds.	Rhyolite and latite folded with Siebert lake beds.		Later rhyolite in places containing augite, not folded with Siebert lake beds.		Later tuffs passing into older alluvium.	Basic andesites.	Basalts in large part contemporaneous with upper part of older alluvium, but ranging from Miocene to Pleistocene.
Timber Mountain			Erosional unconformity, Kawich, Amargosa, Bullfrog, Cactus, Shoshone.	×		Erosion between rhyolite and Siebert lake beds, and locally erosional unconformity between early Miocene rhyolite and Miocene andesite and dacite.					Orogenic movement.		Mature land surface, probably here, at least, prebasaltic			×
Mount Jackson								×	×	×				× ?		×
Bare Mountain		× ?		×												×
Monitor Hills									×							×
Specter Range																×
Yucca Mountain				×												×
Reveille Range				×					(a)							×
Lone Mountain foothills																
Panamint Range														×		×
Hills between Cactus and Kawich ranges				×			×									×
Death Valley									×					×		×
Goldfield hills		×		×			×	×	×			×		×		×
Belted Range		×		×			×		×	×						×
Pahute Mesa				×			×		×	×		×		×		×
Kawich Range		×		×	×		×		[b] ×	×					×	×
Amargosa Range		×		×	×				×	×						×
Bullfrog Hills		×		×	×				(c)					×		×
Cactus Range		×		×			×								×	×
Southern Klondike hills								×	×	×		×		×		×
Stonewall Mountain	×	×							×			×				×
Gold Mountain ridge				×												×
Silver Peak Range							×	×	×							×
Slate Ridge				×								×				×
Tolicha Peak				×												×
Shoshone and Skull mountains		×		×					×	×						×

[a] Probably to north.

[b] Including shore formation.

[c] Shore formation only.

Before the deposition of the Siebert lake beds ceased rhyolites and siliceous latites and dacites outflowed. In some of the ranges these are folded with the lake beds; in others they lie upon the tilted and eroded surfaces of the sediments. During and immediately after the extrusion of these siliceous rocks tuffaceous sediments were deposited in several of the ranges in the northwestern part of the area, and these are in part probably equivalent to the Humboldt series, the deposits of the Shoshone Lake (late Pliocene) of King.[a] The older alluvium, so widely distributed, particularly in the inclosed valleys, represents ancient playa deposits and alluvial slopes of what was probably the Pleistocene residuum of this lake. The early stages of Shoshone Lake were followed immediately by basalt flows which cover wide areas in southwestern Nevada and eastern California. In several of the ranges these basalts were preceded by basic pyroxene andesites. While the basalt is thus largely of late Pliocene age, its extrusion began during the deposition of the Siebert lake beds, basalt flows occurring near the top of these sediments in the Amargosa Range and the Goldfield hills,[b] and probably in the Monitor Hills. Some of the basalt cones are remarkably fresh and are certainly of Pleistocene age, and it is by no means impossible that volcanism has not ceased in this portion of the Basin Range.

The succession of the lavas of the Great Basin has recently been treated at length by Spurr.[c] His succession for the petrographic province of the Great Basin and that of the writer for the portion of that province here treated are practically identical. Both assign the first rhyolite to the end of Cretaceous and to Eocene time. It is believed, however, from the length of time indicated by the complex history of extrusion and erosion intervening between this rhyolite and the deposition of the Siebert lake beds, that the monzonites and acidic andesites may well also be in part Eocene, while the second rhyolite is believed to be largely of early Miocene age. The andesite and dacite are also of comparatively early Miocene age, while the third rhyolite covers the middle and late Miocene and early Pliocene. The basalts range in age from late Miocene to Pleistocene, the major extrusions occurring in late Pliocene and Pleistocene time. As to the genetic relations of the magmas, the writer is wholly in accord with the views of Spurr in the article already cited. He believes that the Tertiary lavas of the Great Basin are the representatives of two complete cycles of the differentiation of a magma of medium composition into acidic and basic lavas and that probably the end of a still earlier cycle is also represented.

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[a] King, Clarence, U. S. Geol. Explor. 40th Par., vol. 1, 1878, pp. 434, 456.

[b] Oral communication from Mr. F. L. Ransome.

[c] Spurr, J. E., Jour. Geol., vol. 8, 1900, pp. 621-646.

PLEISTOCENE AND RECENT.

TRAVERTINE.

At Alkali Spring, 11 miles northwest of Goldfield, is a low dome 200 feet long formed of platy masses of grayish-brown travertine. This was the vent of the spring probably in late Pleistocene time.

DESERT GRAVELS.

The desert gravels cover the surface of the broad valleys above the playas and fill valleys of erosion in the mountains. They extend over about 45 per cent of the area mapped. These detrital deposits are composed of bowlders, pebbles, and sand. Many of the angular or subangular bowlders near the mountains are 6 feet in diameter; near the playas the bowlders grade into pebbles, measuring one-half inch or less. Some bowlders of quartzite show small crescentic fractures, and some of fine-grained limestones show white crushed spots; these are due to the impact of one bowlder against another during rapid transportation such as is characteristic of cloudbursts. Near the mountains the gravels are but slightly stratified, and here cross-bedding and slight erosional unconformities are common. Qn the border of playas layers of small pebbles and sand are regularly interbedded with laminæ of playa clay. The material of these detrital deposits is undecomposed, and if consolidated would form a secondary rock of practically the same chemical composition as the rock from the débris of which it was derived. Calcium carbonate is a common cement particularly adjacent to limestone and basalt outcrops. In a number of the arroyos shelves along the sides and tiny scarps in the channels mark lime-cemented conglomerates. Gypsum and silica also occur as cements at a few places.

The thickness of the desert gravels is unknown. In some of the inclosed valleys lava flows and older alluvium are exposed here and there and probably underlie the valley at no great depth. In other valleys, however, the gravels probably reach a thickness of hundreds and possibly thousands of feet. The Amargosa mine at Bullfrog, which is situated about five-sixteenths of a mile from the rhyolite ridges, has been sunk 330 feet in detrital deposits. Wells have been put down in other valleys to depths of 75 to 275 feet, and, while the records are very imperfect, it is apparent that they have not passed through the desert gravels.

These gravels in large part make up alluvial fans and the contiguous alluvial slopes; in minor part they form cliff taluses. Where no playa exists there is a zone in the center of the valley in which the material is derived from the mountains on both sides, since cloudbursts, first from one range and then from the other, push the débris across the median drainage line.

The desert gravels on the surface are without question still accumulating and are in part of Recent age. Their deposition, however, is slow, and from their thickness it is probable that the lower portions of the formation are of Pleistocene age. The length of time required for their accumulation is indicated not only by the present infrequency of cloudbursts. Embedded in the gravels are pebbles deeply scored by wind erosion on the exposed side, while the under surface is untouched. Such pebbles must have been stationary for long periods. The alluvial fans, with the exception of a single channel, are superficially stained by the black “desert varnish,” a process also requiring a considerable period.

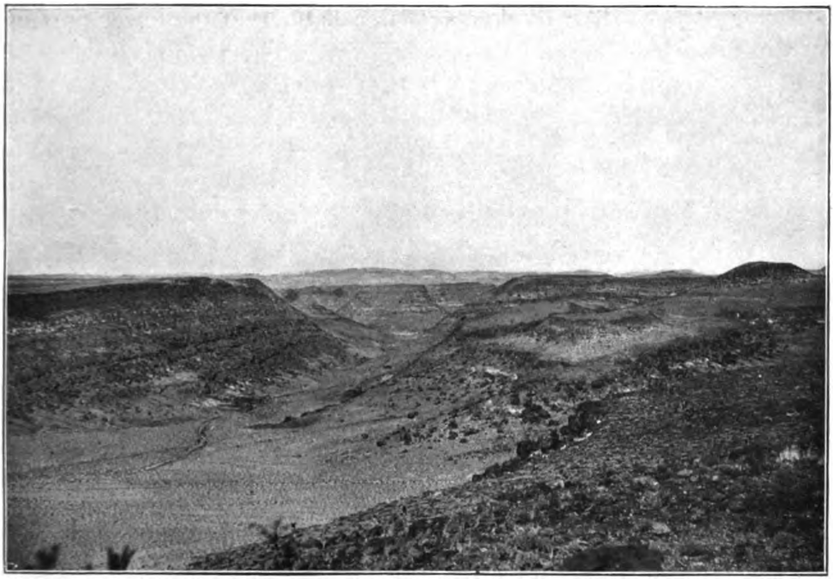
PLAYA DEPOSITS.

Playa deposits composed of light-gray or white fine clay, in many places arenaceous, occupy the bottoms of nearly all the inclosed valleys. Grotesque concretions of calcium carbonate from 1 inch to 8 inches in length are locally embedded in the clay, while some strata are lime cemented. Salt Flat and other areas mapped as playa deposits in Death Valley differ from those just described in the fact that some water continually stands in depressions and that considerable amounts of saline material are being deposited. For convenience several areas in Oasis Valley have been mapped as playa deposits. These areas are occupied by clays, loams, and sands of complex origin, partly playa deposits, partly stream alluvium, and partly wind-deposited sand. The thickness of the playa deposits is unknown, although from their mode of origin it is believed that they are thinner than the desert gravels in the same basin.

During periods of unusual precipitation the playas are wholly or partially covered by water, and at such periods some fine detrital material is washed into them. More or less wind-blown sand becomes mixed with the clay, and on desiccation of the temporary lakes chemical deposits are formed. The playa deposits are of late Pleistocene and Recent age.

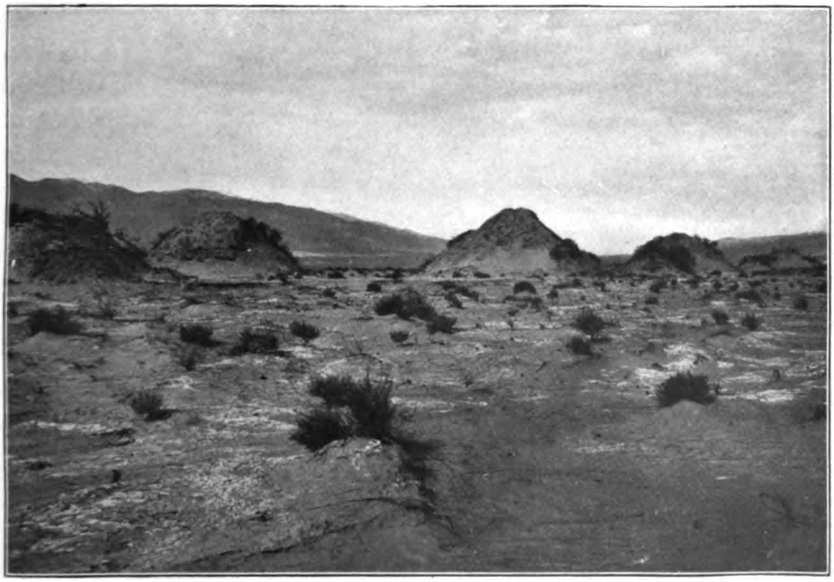
SAND DUNES.

Large sand dunes are confined to the southern portion of the area mapped, although smaller dunes border all the playas. Big Dune, in the Amargosa Desert, is 300 feet high, and lower ones, similarly perfect in contour, occur in Death Valley. These are said to retain their general position from year to year, their situation apparently being determined by wind eddies. Some of the smaller dunes are directly dependent on the desert shrubbery for their existence (Pl. II. *B*), while the position of those on higher ground is evidently determined by the protecting influence of surrounding hills.



PAHUTE MESA

Showing benches determined by resistant flows of basalt.



B. DEATH VALLEY.

Showing sand dunes protected by desert shrubbery (mesquite and creosote bush).

DEFINITIONS OF IGNEOUS ROCKS.

The various igneous rocks which occur in the area under discussion are simply defined below for the benefit of the nontechnical reader.

Alaskite is a granular rock of white or light-gray color. It is composed almost entirely of quartz and orthoclase.[a] It is a granite lacking mica and hornblende.

Andesite is a porphyritic rock; that is, it has visible crystals (phenocrysts) embedded in a finer-grained, often glassy groundmass. The most conspicuous features are the phenocrysts of hornblende or biotite or augite and plagioclase.

Aplite is here applied to a finely granular rock which usually occurs in dikes cutting, for example, a granite. The aplite, which as a rule is more siliceous than the granite, in many instances has solidified from a portion of the granite mass that is still liquid at great depths.

Basalt is a black or dark-gray rock which is often porous through the presence of steam holes. Crystals of olivine, plagioclase, and pyroxene may or may not be visible in the dense or finely granular groundmass.

Dacite may be briefly defined as a quartz-bearing andesite. The more basic dacites closely resemble andesites, while siliceous dacites are closely connected by transition rocks to rhyolite and might be confused with rhyolite were it not for the presence of plagioclase crystals.

Diorite is a gray granular rock which is composed essentially of plagioclase and hornblende, while biotite or augite may also be present. Diorite and andesite are similar chemically, but differ texturally.

Diorite porphyry is a rock of the composition of diorite with abundant crystals of plagioclase, hornblende, and biotite. The groundmass is finely granular.

Granite is a granular rock of pink or gray color. It is composed of orthoclase, quartz, and either muscovite, biotite, or hornblende.

Granite porphyry is a rock of porphyritic habit having the same composition as granite. Quartz and orthoclase are the more common phenocrysts, and these are embedded in a finely granular groundmass.

Latite is a porphyritic rock with more or less glassy groundmass. Phenocrysts of orthoclase and plagioclase are present in equal amounts, while either hornblende, augite, biotite, or olivine is usually also present. Chemically, latite is the equivalent of monzonite.

Monzonite is a granular rock resembling both granite and diorite, but containing orthoclase and plagioclase in approximately equal amounts. If quartz is present, the rock is called a quartz monzonite. It is usually of a gray color.

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[a] Orthoclase (alkali feldspar) is unstriated; plagioclase (soda-lime feldspar) is striated and when light strikes it alternate tiny parallel bands reflect the light simultaneously.

Monzonite porphyry bears the same relation to monzonite as granite porphyry to granite.

Pegmatite is here applied to a coarsely crystalline rock which occurs as dikes in some other rock—granite, for example—with which it practically coincides in composition. Such rocks are probably formed by segregations from the original molten mass of the inclosing igneous rock.

Rhyolite is a porphyritic rock with glassy base. It has the same chemical composition as granite. The most abundant phenocrysts are orthoclase and quartz, although biotite, augite, and hornblende also occur.

Syenite is a granular rock usually of gray color. The component minerals are orthoclase and hornblende or mica. If quartz is present, the rock is called a quartz syenite, and with increase in this constituent quartz syenite passes into granite. Where the component minerals are rich in soda, the rock is a soda syenite.

GEOLOGIC HISTORY.

As has been stated, no pre-Cambrian formations have been found in the area studied, but the Prospect Mountain quartzite in the Specter Range contains pebbles which are in part derived from sedimentary rocks and in part from granite. It may be inferred, therefore, that pre-Cambrian rocks, both sedimentary and igneous, at one time covered areas in southwestern Nevada and eastern California.

In Cambrian and Ordovician time this portion of the Great Basin was part of a sea bottom upon which sandstones and then limestone and finally sandstones were laid down. The sinking of the sea bottom progressed step by step with the deposition of the sediments. King[a] has shown that the eastern border of the land surface from which the sediments were derived was, in the latitude of the fortieth parallel, near 117° 30′ west longitude, while the shore line farther south appears from Spurr's map[b] to have been at about 118° 15′. The early Paleozoic rocks of the area studied contain a greater proportion of sandy sediments, and the limestones are more impure than those described by Hague at Eureka, Nev., facts in harmony with the closer proximity of this area to the old continental shore line. The presence in the lower Paleozoic rocks of ripple marks, cross-bedding, intraformational conglomerates, and oolitic limestones indicates that the sea was for the greater portion of the time shallow, and locally, as evidenced by sun cracks, the deposits were even raised above sea level. The area under consideration was, indeed, so near the ancient shore line, naturally a zone of greatest differential uplift, that islands may have stood at times above the surface of the sea.

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[a] King, Clarence, U. S. Geol. Explor. 40th Par., vol. 1, 1878, p. 247.

[b] Spurr, J. E., Bull. U. S. Geol. Survey No. 208, 1903, Pl. I.

Hague[a] has found in the Eureka district a marked unconformity between the Eureka quartzite and the Lone Mountain limestone, and according to his description younger formations overlap the Eureka quartzite. Such an unconformity was not definitely recognized in the area surveyed, but it probably exists. The apparent absence of Devonian rocks has been already mentioned, and the alternative hypotheses are presented that the area was a land mass during the greater portion of Devonian time, or that Devonian rocks were deposited and later eroded. Spurr found Devonian rocks 18 miles south-southeast of Ash Meadows[b] and 5 miles east of Point of Rocks,[c] and his map shows large Devonian areas from 30 to 40 miles east of the area here considered. Whichever of these hypotheses may be true, it is evident that at some time between the deposition of the Lone Mountain limestone and the Weber conglomerate a land mass existed over a portion at least of southwestern Nevada and eastern California. Not only were the Cambrian, Ordovician, and Silurian rocks uplifted and eroded, but the limestones were cut by calcite veins and in part silicified to jasperoid, and the sandstones were cemented to quartzites prior to their inclusion as pebbles in the Weber conglomerate. Cementation is evident not alone from the presence of these pebbles, but also from the fact that the early Paleozoic quartzites are thoroughly indurated, while the Pennsylvanian sandstones are of more open texture. The earliest Carboniferous rocks exposed in the area studied are of Pennsylvanian age, and it is evident that during that period the area again formed the bottom of a sea, which, however, during the deposition of the Weber conglomerate could not have been far from a land mass, while a conglomerate in the Pennsylvanian limestone also indicates shallow-water conditions. After the deposition of this limestone the area was probably lifted above the sea and never sank beneath it again. The period of Paleozoic sedimentation thus concluded was unattended by volcanism, with the possible exception of that which produced the metamorphosed basic igneous rocks of the Amargosa Range.

King[d] believed that contemporaneously with the emergence of this portion of the Great Basin above the sea the old land mass to the west subsided and that upon it were deposited Triassic and Jurassic rocks. He further believed[e] that the ranges of western Nevada were formed at the same time as the Sierra Nevada, or at the close of the Jurassic. This seems very probable from the general parallelism of the Nevada ranges with the Sierra Nevada crest line, particularly since some of the ranges west of the area surveyed are composed of folded Triassic and Jurassic rocks. At this time the Paleozoic rocks were complexly folded, the larger proportion of the flexures striking west of north. The folding in some places is close and in others open, being particularly intense in the ranges nearer the Sierra, such as the Panamint and Amargosa ranges. It was accompanied by reverse faulting. These post-Jurassic structural lines have ever since their formation proved to be lines of weakness, of which advantage has been taken by later deformation.

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[a] Hague, Arnold, Mon. U. S. Geol. Survey, vol. 20, 1892, p. 57.

[b] Spurr, J. E., Bull. U. S. Geol. Survey No. 208, 1903, pp. 197–198.

[c] Op. cit., p. 161.

[d] King, Clarence, U. S. Geol. Explor. 40th Par., vol. 1, 1878, p. 759.

[e] Op. cit., p. 747.

After considerable folding had taken place, and probably before the end of the deformation, granitoid rocks were intruded into the Paleozoic strata. That the granite intrusion was a late event in the deformation is indicated by the massive character of that rock. The intrusion was accompanied by local buckling of strata, by contact metamorphism, and somewhat less directly by ore deposition. It was followed by the intrusion of a quartz-monzonite porphyry, and later of diorite porphyry and diorite.

A long period of erosion, extending at least to Eocene time, followed the post-Jurassic folding and consequent mountain building. This period was probably one of heavy rainfall and large rivers. No estimate can be formed of the amount of erosion, but it was sufficient to remove from the granite the covering beneath which it solidified. Notwithstanding the length of this erosion period no peneplain was formed; from this it is inferred that the area was subjected to successive uplifts while being eroded. Where exposed beneath the oldest Tertiary formation the Palezoic rocks appear to have been eroded into mountain ranges, many of which have a north-south extension. Some of these mountains of Paleozoic rocks—for example, the Kawich Range—were fully as high and rugged as the present ranges.

The Eocene inaugurated the Tertiary period of volcanism and lake sedimentation processes, accompanied by important deformation, erosion, and ore deposition. The Tertiary igneous rocks, being largely in flows, in contradistinction to the intrusive post-Jurassic rocks, produced but little contact metamorphism. The permanency of the structural lines, initiated probably in early Cretaceous time, has already been mentioned. Along these lines the Tertiary deformation occurred, while many of the main lava extrusions burst from north-south vents along pre-Tertiary mountain ridges. The first lava to outflow was a rhyolite, which was followed by monzonites and acidic andesites, in part intrusive bodies. Next there was an important and probably long erosional interval, followed by a mighty extrusion of rhyolite, which equals or exceeds in bulk the basalt outflow of late Pliocene and early Pleistocene time. The rhyolite in turn was followed by andesites and dacites, and these by unimportant rhyolites, immediately preceding the deposition of the Siebert lake beds in the Pahute Lake. It was probably during this general period that the most important ore deposits in the Tertiary rocks were formed, presumably by waters heated by the still-hot magmas. Between the outflow of the rhyolite and the formation of the Pahute Lake erosion was probably continuous, partially accounting for the formation of the lake basin which in the main, however, originated through orogenic sinking that was possibly, in part, consequent on adjustments due to the extrusion of immense masses of lava, a hypothesis suggested by Spurr.[a] The Pahute Lake covered practically the whole area surveyed, although the presence of coarse conglomerates in the Kawich and Amargosa ranges and the Bullfrog Hills indicates that rugged islands rose above the surface of the lake. Wherever the former shores of the lake are now seen it is evident that the surface of the older rocks was uneven and that each island was surrounded by islets. The climate must have been moist and the presence of fossilized wood in the lake beds shows that trees flourished near its shores. While the lake was thus for the most part fresh, periods of aridity alternated with those of comparative humidity, and the lake or portions of it were partially desiccated, permitting the local precipitation of limestone, gypsum, and boron minerals. Volcanic flows and explosive eruptions of rhyolitic material occurred at various times during the existence of the lake. The Pahute Lake was destroyed in part by the increasing aridity of the climate and in part by deformation, which was accompanied and immediately followed by the extrusion of rhyolite. By this deformation the whole area was uplifted with attendant southward tilting, which accounts for the relatively low altitudes occupied by the Siebert lake beds in the southern portion of southwestern Nevada. Furthermore, the deformation, by differential uplift, blocked out the mountain ranges as they now appear and formed many of the inclosed valleys by broad folding or warping. Death Valley was at this time first outlined, though it was depressed later, probably in the late Pliocene or early Pleistocene time, by block faulting.

Extensive erosion followed and before the end of Pliocene time it had reduced the surface to mature and comparatively gentle topography. In restricted areas the Pliocene-Pleistocene basalt appears to have flowed upon a local peneplain. In late Pliocene time the climate was moist and a shallow lake probably covered a considerable area in the vicinity of Goldfield. The older alluvium, a formation widely distributed over the area, may be considered as deposits of the waning stages of this lake period in the inclosed valleys. Toward the end of this period the basalt extrusion reached its climax. Uplift accompanied by normal faulting and folding followed the deposition of the older alluvium, and at this time erosion appears to have been very active.

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[a] Spurr, J. E., Prof. Paper U. S. Geol. Survey No. 42, 1905, pp. 52–53.

In Recent time the erosion characteristic of arid lands has partially filled the inclosed valleys with bowlders, gravels, and sands—débris from the wasting mountains—and the process is still going on.

The ranges of this portion of the Great Basin were delineated by post-Jurassic folding and Cretaceous erosion. Later uplift, coupled with volcanic outbursts along these same structural lines, has added much to their height, and the effect of these processes has been emphasized by the deepening of the intermontane valleys by erosion. In Death Valley alone does faulting appear to have been the dominant process in blocking out the existing topographic forms. The unimportance of faulting in the topographic evolution elsewhere is well exhibited in the northeast quarter of the area surveyed. The Paleozoic rocks of the Kawich and the Belted and Reveille ranges are folded in a syncline with its trough in the Kawich and Reveille valleys. The presence of early Miocene rhyolites in the Cactus, Kawich, Reveille, and Belted ranges at approximately equal elevations further proves that, unless compensating faults are hidden in the intervening inclosed valleys, faults have been of little moment. The projection of minor transverse ridges from the main ranges into the desert valleys and the frequently observed gradation from small erosional buttes to groups of rounded hills, such as the Monitor Hills, and from these to such elevations as the Cactus Range, are also opposed to the view that the principal mountain masses have been bodily uplifted by great faults. The ascendency of erosion over faulting is further indicated by the broad and rounded detrital embayments which notch many of the ranges.

ECONOMIC GEOLOGY.

HISTORY OF MINING DEVELOPMENT.

Two waves of activity in prospecting and mining have passed over the portions of Nevada and California under consideration. The first started in the late sixties, reached its maximum height in the seventies, and died out before 1890. The hardy prospector and miner in these years confined his attention to the Paleozoic limestones and the post-Jurassic granites. Lida, Old Camp, and Montezuma were flourishing mining centers. Mining in the area studied was dormant in the nineties, but with the discovery of Tonopah's phenomenal veins in 1900 the desert region was attacked with new ardor. The Tertiary eruptives have been more especially the chosen field of the prospector, although the limestones and granites have been by no means neglected.

ECONOMIC CONDITIONS.

The various camps herein described are connected with supply points by wagon roads, most of them surprisingly good considering the fact that many are less than a year old. Some mines have a small but for the present sufficient water supply near at hand. Other camps are compelled to haul their water from springs or seeps 20 miles distant. Piñon and juniper are rarely of sufficient size for mine timbers, other than stulls, but piñon makes an excellent fuel. The power question will probably be solved at the other successful camps, as it has been at Goldfield, by the transmission of electricity

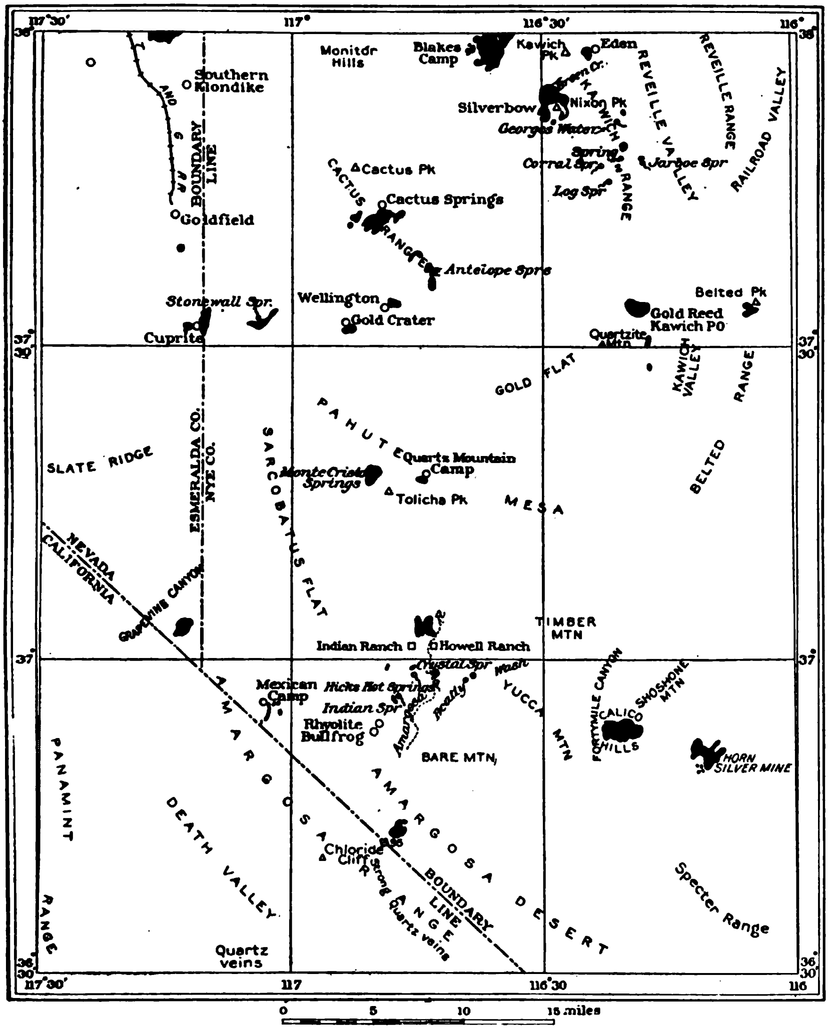

FIG. 4.—Economic map showing areas of altered Tertiary rocks.

generated on the swift streams of the Sierra Nevada. The heat of July and August renders surface work in those months almost impossible in the more southern camps.

GENERAL CHARACTER OF THE ORE DEPOSITS.

The ore deposits herein described are apparently the work of two distinct main periods of mineralization, one post-Jurassic and pre-Tertiary, the other Tertiary. The veins at Chloride Cliff may, indeed, be pre-Jurassic, but their resemblance to the post-Jurassic veins renders this questionable.

POST-JURASSIC AND PRE-TERTIARY DEPOSITS.

(A) DEPOSITS IN GRANITE.

1. Pegmatitic dikes: Dikes of pegmatite at Oak Spring are reported to carry gold and silver values. These, so far, have proved unimportant.
2. Reopened pegmatitic dikes: The quartz, itself of pegmatitic origin, has been crushed, and the veins are probably due to the same period of mineralization as that which formed the deposits described in the next paragraph. The deposits of Lime Point and some of those at Trappmans Camp are of this origin.
3. Massive quartz veins in fissures, joints, and irregular zones of brecciation: The quartz is not crustified. The chief sulphide is pyrite, although galena, chalcopyrite, and sphalerite occur locally. The deposits are usually gold bearing, but with the introduction of galena silver values may predominate. The ores were deposited by water, which may have been remotely connected with the granitic intrusion. The sharp contact with the comparatively unaltered wall rock indicates that these veins filled open fissures. Such appear to be the deposits at Old Camp and some of those at Trappmans Camp, Oak Spring, and Southern Klondike. The deposits of Goldbelt are in quartz monzonite. In the past the veins at Old Camp have been large producers.
4. Impregnation of pyrite along joints: This is an unimportant form of deposit seen only at Trappmans Camp.

(B) DEPOSITS IN PALEOZOIC SEDIMENTARY ROCKS, PREDOMINANTLY LIMESTONE.

1. Quartz veins and irregular masses occupying faults, joints, bedding planes, and brecciated zones, as a rule in the neighborhood of granitic intrusions: Rarely a little calcite is associated with the quartz. The original sulphides deposited in the quartz include chalcopyrite, galena, pyrite, and sphalerite, while telluride was probably originally present in some deposits. In the veins in limestone the predominant sulphides are chalcopyrite and galena and the

values largely silver. In quartzite and schist, in metamorphosed limestones composed of quartz, garnet, epidote, and calcite, and in limestone zones in which silification extended beyond the quartz vein pyrite is the predominant sulphide, with gold values alone or in excess of silver. It is probable that the relative abundance and variety of sulphides were determined by the wall rock, the more siliceous rock tending to precipitate from the waters auriferous pyrite and the calcareous rock precipitating argentiferous galena and chalcopyrite. The secondary ores of this subdivision include malachite, azurite, chrysocolla, native copper, brochantite, cerussite, emmonsite (or durdenite), native gold, and horn silver, while chlorobromides of silver are reported. Chalcocite is probably of secondary origin. Two or more of these ores are associated with hematite and limonite or with a heavily stained jaspery quartz with conchoidal fracture. Gypsum, and at one place sulphur, are secondary gangues of less wide distribution. The secondary minerals replace the wall rock and in part fill open fissures. In many places cavities in the secondary ores are frosted by later quartz crystals. The Tokop veins belong to this subdivision and their similarity to veins in the granite of Old Camp and their reported extension into the granite beneath indicate that the quartz veins in the granite and limestone are contemporaneous in age and of like origin, a conclusion entirely in accord with the character of both the gangues and ores of types A 3 and B 1. The quartz veins in the granite (A 3) are not demonstrably of pegmatitic origin and yet their form, here lenslike, there sigmoid and independent of apparent faulting, is, in many instances, more closely allied to that of a pegmatite dike than to that of a water-deposited vein. In the Paleozoic rocks surrounding granite masses these quartz veins are abundant, a fact exemplified by the clustering of mining camps around the post-Jurassic intrusive masses. At a distance from the granite the veins decrease in number and in size, and finally the same ores replacing the limestone occur without quartz, as at Cuprite. It is probable that the quartz veins in granite and limestone were deposited by heated waters, in part at least the magmatic waters of the granite, but much more remotely connected with the magma than those which formed the pegmatite dikes. The resemblance between the ores of these veins and those of the veins along contacts (B 3) is striking. The latter deposits may have been laid down by waters from portions of the granite deeply buried and still molten, or by waters from the white quartz-monzonite porphyry, an igneous rock probably genetically related to the granite.

The Lida, Bare Mountain, and Oriental Wash deposits, and some of those of Chloride Cliff, Montezuma, Oak Spring, and Southern

Klondike, are of this type. These deposits were the most important source of ore in the seventies and eighties.

2. Replacement deposits: In the Cuprite mining district and to a less extent in the General Thomas mine, in the Lone Mountain foothills, the sulphides appear to replace the limestone in irregular masses. The Cuprite deposits are at a considerable distance from granite, and in these quartz is lacking. The same ores are found here as in other deposits in the sedimentary rocks, and it is believed that the ore deposits of Cuprite were formed contemporaneously with those of the type B 1 by similar waters, which, however, had deposited their silica before journeying so far from the granite mass.

3. Veins along contacts: Deposits along contacts occur in the limestone along dikes and sheets of monzonite and diorite porphyry in the northwestern part of the area mapped, and along a mass of hornblende schist at Chloride Cliff. The porphyries are almost certainly pre-Tertiary and the mineral association is so similar to that in the deposits already described (B 1 and 2) that there can be but small doubt of at least a remote genetic relation in the origin of the two. The General Thomas and some of the Montezuma prospects are of this type.

TERTIARY DEPOSITS.

(C) GOLD DEPOSITS IN SILICIFIED MONZONITE PORPHYRY AND RELATED ROCKS.

Gold occurs at Kawich and Gold Crater, respectively, in silicified and kaolinized monzonite porphyry and biotite andesite. When the igneous rock was silicified pyrite was deposited in open fissures in it and probably partially replaced it. Disseminated pyrite occurs beyond the silicified zone. Copper sulphide is unimportant, and galena is apparently not present. Kaolinization is probably a later process. During the surface alteration of the pyrite free gold lodged in the cavities of the altered rock and at Gold Crater was deposited along joints in the surrounding iron-stained andesite. The quartz-monzonite porphyry of Shoshone and Skull mountains is similarly silicified. The ores of Kawich and Gold Crater were deposited by ascending hot waters carrying silica in solution, and while the waters were similar chemically, it by no means follows that the deposits are contemporaneous, since the country rock in the one case was probably of Eocene and in the other of Miocene age.

(D) DEPOSITS IN RHYOLITE.

1. Silver- and gold-bearing quartz veins in silicified and kaolinized rhyolite: At Silverbow, Eden, Cactus Spring, Wilsons Camp, Stonewall Mountain, and Wellington vuggy quartz veins, many of them with crustification well developed, fill fault fissures, joint planes, and cavities of brecciation and solution. These veins grade along their strike into zones of silicified rhyolite carrying gold and

silver values. The ore deposits of these camps, if not demonstrably of contemporaneous origin, were formed by physically similar waters. The original sulphides include stephanite, iron pyrites, and chalcopyrite. Pyrargyrite, also noted, may be secondary. From the primary ores free gold, horn silver, malachite, azurite, limonite, and hematite are derived. The relative abundance of silver sulphides or of pyrite determines whether the veins carry predominant silver or gold values. In the same camp structurally similar veins may carry either gold or silver and in various parts of the same vein the proportion of the two metals differs greatly. A little calcite is associated with quartz in some veins, and at Silverbow and Eden quartz bodies suggestive of the crystal form of calcite probably indicate its former presence. Irregular zones or areas surrounding these veins are either silicified or kaolinized, the former process having been contemporaneous with ore deposition, the latter, in certain cases at least, subsequent to it. The contact with the vein quartz is in some cases transitional, in others sharp. In all the camps these zones of altered rock are much more extensive than the ore deposits, and ore deposition unaccompanied by either silicification or kaolinization has apparently not occurred. The silicified rhyolite is white in color, flinty in texture, and without prominent phenocrysts, although careful inspection shows the presence of quartz phenocrysts, while weathered surfaces show feldspar casts. In some instances the slightly smoky quartz phenocrysts alone retain their identity. Some of the altered rhyolite is so dense that the Indians have used it in making arrowheads. During the deformation of the rocks after silicification the brittleness resulting from the density of this conchoidally fracturing rock was an important factor in the production of numerous cracks which furnished channels to surface oxidizing waters. Cavities of solution and the interstices of brecciated zones are lined with clear quartz crystals or filled with quartz masses. The alteration has taken place along joints and faults and in bands between joints. The silicified rhyolite, being much more resistant to weathering than the unaltered rock, stands up in rugged walls and knobs whose extent is coincident with that of the silicification. The peculiar topography resulting is well seen in the domical hills three-fourths of a mile east of north of Silverbow. Here there are rugged walls from 1 to 5 feet high, while cross walls show that silicification has also occurred along minor fractures between the main joints.

Under the microscope the silicified rhyolite shows a mosaic of quartz or chalcedony notably uneven in grain, while coarser mosaics or limonite-lined cavities represent the biotite and feldspar phenocrysts, although in some specimens biotite is replaced by muscovite and limonite. The silicified rhyolite of the Cactus Range, south of the

Goldfield-Cactus Spring road, presents features of considerable interest. The groundmass is composed in part of secondary interlocking plates of orthoclase micropoikilitically inclosing quartz blebs and in part of a secondary microgranitic mosaic of quartz and orthoclase varying greatly in grain throughout the rock. Alunite in grains is scattered through the groundmass. A few orthoclase phenocrysts are unaltered, but most of them are changed to an aggregate of alunite crystals and quartz granules. The rock appears to have suffered through recrystallization, with the introduction of sulphurous or a related acid and probably some silica. A thin section of the altered rhyolite from the Calico Hills, near Shoshone and Skull mountains, is somewhat different. The original rock was a glass containing numerous tabular orthoclase crystals and deeply embayed quartz grains. Chalcedonic quartz has replaced some of the feldspar phenocrysts, and with it, forming pseudomorphs after other feldspar phenocrysts and occurring scattered throughout the groundmass, are tiny irregular specks and granular aggregates of a mineral too small for satisfactory determination, probably scapolite. It is evidently contemporaneous with the chalcedonic quartz, and its even distribution throughout the rock shows that the solutions which deposited it must have saturated the whole rhyolite mass. The kaolinized rhyolite is a white, chalky, rather incoherent rock. The feldspar phenocrysts pass to a white unctuous substance and are finally completely removed, forming casts, and the biotite changes to a silvery micaceous mineral.

These quartz veins, the fillings of open fissures, and the attendant silicification of the country rock are evidently due to ascending heated waters which carried, in addition to metallic salts, notable quantities of silica, while locally they contained salts of calcium as well as fluorine, sulphurous acid and chlorine. The presence of the fluorine is indicated by the alteration of biotite to muscovite; sulphurous acid is a constituent of alunite and chlorine of scapolite. The waters in part, then, were of magmatic origin and contained gases typical of waning volcanism. These ore deposits, except those in the rhyolite of Stonewall Mountain and that to the north of Cuprite and some of those in the Southern Klondike hills, occur in the early Miocene rhyolite. But at Wellington and Wilsons Camp silicification appears to affect not alone this rhyolite, but the succeeding formation, the biotite andesite. This shows that at these places either the silicification was dependent on the magmatic waters derived from andesite or it occurred long after the extrusion of the rhyolite, probably through waters ascending from warm or hot portions of the rhyolite buried at considerable depths. The presence of silicified reefs in the Siebert lake beds in the Silver Peak Range and on Shoshone Mountain is a phenomenon probably of later origin.

Ore deposits of this type are now being extensively worked throughout southwestern Nevada and eastern California. As they have many analogies with those of Goldfield and Bullfrog, other important camps will without doubt be developed.

2. Gold ores in fault zones: At Blakes Camp free gold has been panned from crushed rhyolite along a fault. The iron pyrite was probably originally disseminated in the crushed zone.

3. Gold ores along contacts of Tertiary lavas and Paleozoic limestone: A quartz vein at Southern Klondike is situated along the contact of rhyolite with Cambrian limestone. At the Happy Hooligan mine free gold occurs in decomposed rock at the contact of basalt with Pogonip limestone.

AIDS TO PROSPECTING.

Ore deposits in the area under consideration appear to be confined to the Paleozoic rocks, the post-Jurassic granitoid rocks, and the older Tertiary lavas. Of the Paleozoic rocks the limestones have so far been and probably in the future will be the most favorable country rocks. As an exception to the above, however, it should be stated that the Cambrian quartzite-schist-limestone series in the southern Amargosa and Panamint ranges contains strong quartz veins. Of the post-Jurassic granitoid rocks the granites appear to be more favorable to ore deposits than the quartz monzonites. Of the Tertiary rocks the first and second rhyolites and the andesitic rocks immediately preceding and succeeding the second rhyolite have alone up to the present time proved productive. The rhyolites younger than the Siebert lake beds have, however, in two known instances been silicified and slightly mineralized.

The various formations recognized in southwestern Nevada and eastern California are represented by appropriate colors and patterns on the geologic map (Pl. I), from which the approximate distribution of the various rocks may be determined.

In prospecting in the Paleozoic rocks the limestones should be given preference. Mining experience in this region indicates that the most favorable portions of the limestone are those nearest igneous rocks, not only the larger intrusive masses, but the dikes as well. Such dikes are common in the Cambrian rocks from Lida to the General Thomas Camp. The abundance of ore deposits appears to depend almost directly on proximity to igneous rocks, and to this Cuprite alone seems an exception. Most of the ore deposits in the Paleozoic rocks are found in well-defined quartz veins, but some deposits are marked by heavy "gossans" (hydrated masses of spongy iron ores of red or brown color).

The map (Pl. I) shows the areas in which the older Tertiary lavas are known to occur, and, while many areas have doubtless been missed in the present rapid survey, it is believed that the larger ones have been mapped. The ore deposits within these older rhyolites and andesites, so far as is at present known, are contained in the silicified and kaolinized portions. These are shown in fig. 4, although it is certain that many others exist which were not encountered in the course of the present work. In searching for such areas of altered rock, the peculiar rugged topography with its walls (commonly called "dikes" by prospectors) and pinnacles (see p. 47) will be helpful in many instances. The compact, flinty texture of the silicified rocks, already described (see p. 47), is very characteristic. In the Kawich Range, Paleozoic quartzite has been mistaken by some for silicified rhyolite. The quartzite, however, can be distinguished by its more glassy appearance as well as by the presence in it of rounded sand grains or pebbles. In both the silicified rhyolite and the monzonitic and andesitic rocks veins occupy fault fissures, and prospect trenches and pits located on such faults often bring good results. Within the silicified rhyolite in particular quartz veins should be carefully assayed, as in this quartz the values in the rhyolite camps usually lie. Further, a yellow scaly coating similar to that from Goldfield, determined by Dr. W. F. Hillebrand[a] as a basic ferric-alkali sulphate, appears to be confined to joints in the immediate vicinity of ore deposits in rhyolite.

DESCRIPTIVE GEOLOGY.

In this section the different localities are described in the following order: The mountain ranges and valleys in the vicinity of Goldfield; those to the north of Pahute Mesa; the mesa itself; the mountain ranges to the south of Pahute Mesa; the Amargosa Mountain system; Death Valley; and the Panamint Range.

REGION ABOUT GOLDFIELD.

In the northwest quarter of the area shown on the map, in the vicinity of Goldfield, are the Lone Mountain foothills, the Silver Peak Range, the Mount Jackson, Goldfield, and Southern Klondike hills, and Stonewall Mountain. The hills are characterized by a north-south extension, the trend verging toward northeast in several instances. Geologically they are marked by important developments of the Cambrian rocks and the Siebert lake beds.

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[a] Bull. U. S. Geol. Survey No. 260, 1905, p. 137.

LONE MOUNTAIN FOOTHILLS.

TOPOGRAPHY AND GEOGRAPHY.

Lone Mountain is a prominent craggy peak 9,121 feet high, situated immediately north of the northwest corner of the area mapped. While this mountain and its foothills are cut off from the Silver Peak Range to the southwest by the detritus-filled pass 7 miles northwest of Montezuma, the two mountain masses are geologically and topographically closely related. For convenience, the long ridge in which General Thomas Camp is situated will also be described here.

The Lone Mountain foothills reach a maximum elevation of 7,600 feet. They have rather steep slopes and show a tendency to elongation parallel to the strike of the Paleozoic rocks. The eastern ridge has a serrated crest line, due to the alternation of steeply dipping resistant limestones and soft shales. The Lone Mountain foothills are bare of timber and without water, although both are present on the mountain itself.

GENERAL GEOLOGY.

Lone Mountain is a batholith of granite which intrudes Cambrian sedimentary rocks, the predominant rocks of the foothills. The formations are as follows, the oldest being named first: Cambrian sedimentary rocks, post-Jurassic granite, pre-Tertiary diorite and diorite porphyry and associated serpentine, and older alluvium.

SEDIMENTARY ROCKS.

Cambrian.—The predominant formation of these hills is a series of limestones and shales which appears to consist of a lower shale member, at least 1,000 feet thick, and an upper limestone, several thousand feet thick, which in turn is probably overlain by a second shale member.

The limestone is compact and rather fine grained. It is dark gray or bluish gray in color, although in places weathered surfaces are stained yellow or brown by limonite. It is for the most part probably dolomitic, since an analysis of a limestone from the westward extension of the area, in the Silver Peak quadrangle,[a] showed 19 per cent of magnesia. Layers of black flint, from a few inches to 2 feet thick, are interbedded with the limestones near General Thomas Camp. In the same vicinity the limestone has been altered to a white cherty quartz and all gradations exist between this and the unsilicified limestones. White calcite veins traverse the limestone in all directions, while quartz veins are less common. These veins are not folded, and are doubtless younger than the folding.

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[a] Turner, H. W., Silver Peak folio; unpublished.

The shale is fine grained and thin bedded. It is in most places olive green, although locally brilliant rose or purplish pink, while red is imparted to weathered exposures by iron stains. Arenaceous facies are rare. Rather commonly the shale breaks down into pencils which are produced by the intersection of two closely spaced joint systems and bedding planes. Veins in the shale are usually quartz.

No fossils were found in these beds, but on lithologic grounds they are probably Lower Cambrian. Turner[a] so considers the extension of these rocks in the adjoining Silver Peak quadrangle.

Older alluvium.—The road from Alkali Spring to Lone Mountain passes through a gap in the ridge south of the General Thomas mine. The saddle and the low hills on either side are composed of fragmental material lithologically like the Recent alluvium deposits, except that it is somewhat weathered. Erosion has cut it into a number of low hills. This deposit is the remnant of an old alluvial slope, and is tentatively correlated with the older alluvium of Pliocene-Pleistocene age in Death Valley.

IGNEOUS ROCKS.

Granite.—Lone Mountain is a batholith of granite which has pushed up the Cambrian rocks on its border, and into these apophyses extend. The batholith covers about 14 square miles at the northwest corner of the area mapped.

The granite is light gray in color and of either medium or coarse grain. The constituents, which in coarse-grained types reach a maximum diameter of one-half inch, are white feldspar, smoky quartz, and biotite. Phenocrystic feldspars 2 inches long and one-half inch wide are locally present. In some exposures the constituents possess a parallel arrangement, probably original. Epidote films are developed along some joint surfaces, while on others flattened, distorted cubes of limonite after pyrite occur. Muscovite films cover planes of movement.

An excellent sheeting, the joints being from 1 to 3 feet apart, cuts the granite and imparts to many portions of Lone Mountain a sedimentary aspect. The granite weathers into rounded slablike joint blocks stained by limonite, and in consequence the mountain mass is yellowish white in color. The mountain itself has a very rugged topography characterized by knife-edge divides and deep-cut, steep valleys. The foothills and inliers in the wash have strong tendencies to dome form.

Under the microscope the granite is seen to be uneven grained and rather poor in both biotite and quartz. With orthoclase and microcline is a little oligoclase. Titanite rhomboids are very abundant, and the other accessory minerals are magnetite, apatite, and zircon. Quartz shows rather strong undulatory extinction. The rock is somewhat altered, biotite changing to chlorite, orthoclase and microcline to muscovite, and oligoclase to zoisite.

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[a] Op. cit.

The granite is cut by aplite and grades into pegmatite. The aplite is a white, fine-grained rock composed of white feldspar and some quartz. It forms dikes from one-half inch to 2 inches wide, which weather in relief. The constituent minerals of the pegmatite reach a maximum diameter of 1 inch. Some veins of pegmatitic quartz are also present, as is graphic granite, with characters one-fourth inch in length.

At the contact the Cambrian rocks are rather highly metamorphosed. The impure limestone is altered to a quartz-epidote rock in which brown garnet occurs locally. The microscope shows that magnetite and pyrite are also present. The shale is metamorphosed to a silvery knotted schist. In thin section it is found to be a chlorite-epidote schist in which chlorite, quartz, and orthoclase form an interlocking mosaic. Epidote with a little zoisite is equally abundant, although less evenly distributed. Magnetite grains and a few fibrous scapolite aggregates are also present. Veinlets and lenses of coarser quartz, epidote, and zoisite appear to form the "knots."

The granite cuts Cambrian rocks and is itself cut by dikes of diorite porphyry. It is presumably one of the post-Jurassic granites.

Diorite and diorite porphyry.—A small intrusive mass of diorite cuts the granite and another the Cambrian rocks northwest of General Thomas Camp. The diorite appears to be a granitoid rock composed of feldspar and hornblende. The microscope shows that the feldspar is a rather basic labradorite in crystals, with some orthoclase. The hornblende is rudely idiomorphic. Some quartz and magnetite are present, the rock approaching a granodiorite. Epidote and chlorite are secondary to plagioclase and hornblende.

The granite of Lone Mountain is also cut by dikes of a greenish-gray diorite porphyry, which breaks into angular joint blocks with a slight tendency to spheroidal weathering. The dikes, which are from 2 to 20 feet wide, weather in troughs beneath the surface of the granite.

Under the microscope the groundmass appears as small plagioclase laths, between which are some orthoclase grains. The phenocrysts include hornblende, plagioclase (labradorite-andesine), and titanite. Many of the simple plagioclase crystals, which are more or less altered to sericite, calcite, and chlorite, are twinned according to the Carlsbad law. The brown hornblende phenocrysts are partially altered to calcite, chlorite, and iron ores. Apatite and magnetite are accessories.

Sheets and dikes of diorite porphyry, with abundant phenocrysts of striated feldspar and fewer of hornblende, occur in the vicinity of General Thomas Camp, their strike coinciding with that of the Cambrian rocks. The largest masses reach a thickness of 25 feet. Similar dikes cut Cambrian rocks north of the summit on the road from Alkali Spring to Silver Peak.

Pieces of greenish-black serpentine are common on the hills formed of the older alluvium, although the rock was not seen in place. Under the microscope the magnetite and hematite masses associated with the serpentine are seen to be lacking in certain areas, and the texture rather suggests that of an igneous rock. In the Silver Peak quadrangle Turner[a] found a small mass of serpentine in the Lone Mountain foothills. The original rock of each of these occurrences was probably a pyroxenite, genetically related to the diorite.

The diorite and diorite porphyry are probably of post-Jurassic and pre-Tertiary age.

STRUCTURE.

The Cambrian rocks are strongly and complexly folded. The axes of the main folds course east of north; those of the minor folds, east and west. The folding is particularly intense along the border of the area here discussed. Fan folds and isoclinals are common, and in many places these are arranged en échelon. Numerous minor faults and zones of brecciation occur in the Cambrian rocks, but faults of large throw were not noted. The injection of the Lone Mountain batholith has induced in the near-lying sediments a strike parallel to its boundary.

While it is probable that the Cambrian rocks were somewhat folded prior to the intrusion of the granite, the major folding can probably be referred to that intrusion. The position of the older alluvium, 300 feet above the Recent alluvium deposits, shows that the range was considerably uplifted in Pleistocene time.

ECONOMIC GEOLOGY.

The location of the General Thomas mine, the property of the Tonopah-Belcher Mining Company, is shown on the map. When visited by the writer (June, 1905) the mine was closed down. Several inclines follow the steeply dipping beds of limestone and shale, into which in the vicinity are injected sheets of diorite porphyry. Cerussite, malachite, azurite, and chrysocolla in limestone, heavily stained by limonite, lie on the dump. The gypsum associated with the ore was evidently formed simultaneously with these secondary minerals. Galena and pyrite in calcite were the only original sulphides seen, but some copper sulphide must also occur. Lakes[b] states that lenticular bodies of "sand" carbonate of lead, containing nodules of unaltered galena, lay along the contact of porphyry and limestone as well as in the limestone itself. The ore is said to carry high silver values, a carload shipment in January, 1904, having netted $4,300. At that time the shaft was 150 feet deep. The resemblance of this deposit to some of those at Montezuma may be noted. The surrounding hills are bare of timber, and water is scarce. Tonopah and Goldfield are the supply points of these prospects.

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[a] Turner, H. W., Silver Peak folio; unpublished.

[b] Lakes, Arthur, Min. and Sci. Press, vol. 88, 1904, p. 246.

The hills near General Thomas Camp have already been located. An abandoned tunnel 150 feet long has been driven into the diorite mass 1 mile northwest of the General Thomas. The tunnel was not visited, but ore collected by Messrs. Chapman and Spaulding consists of galena, azurite, malachite, and limonite, which appear to fill cavities in the diorite. In the older alluvium the writer found limonite float heavily stained by malachite. This doubtless comes from the hills to the north or south of the road.

NORTHEASTERN EXTENSION OF THE SILVER PEAK RANGE.

TOPOGRAPHY AND GEOGRAPHY.

The mountains north of Lida and south of the valley in which the Klondike Well is situated form the northeast tip of the crescentic Silver Peak Range, which lies mainly to the west of the area surveyed. These mountains are cut off from the Lone Mountain foothills by the detritus-covered pass 7 miles northwest of Montezuma; they are separated from Mount Jackson by a similar gap, and a basalt mesa bridges the interval between them and the Goldfield hills. There are three main ridges, which course N. 30° E., parallel to the predominant strike of the Cambrian rocks. The crest lines average 7,500 feet in height, although Montezuma Peak reaches 8,426 feet. The ridges are, for the most part, rather smooth, although where the strike of the Cambrian rocks crosses them rugged squared hills and pinnacles are common. The hills formed of the Siebert lake beds are conical peaks and gentle domes with broad valleys between. The north-south valley southwest of Montezuma Peak follows approximately the crushed zone along a fault of considerable displacement. Lida Valley is an interesting example of stream capture. The traveler going up the valley from the flat north of Slate Ridge first encounters a narrow canyon. One-eighth of a mile east of Lida the gulch suddenly opens into a gently sloping valley 1 mile wide. The youth of the canyon and the maturity of the valley suggest stream capture, and Spurr, who followed the road westward, believes that the upper broader portion originally drained westward to Fish Lake Valley.

The mountains are covered with piñon and juniper above an altitude which varies from 6,500 feet at Lida to 6,800 feet on the east side of Montezuma Peak. A little grass grows on the upper alluvial slopes and the inter-ridge valleys. An abandoned shaft at Montezuma is filled with good water, and a tunnel near by furnishes a little stock water tainted with ferrous sulphate. Alkali Spring has already been described (p. 19). Springs flow from the mountain slopes near Lida, and the water table in the canyon below the village is in many places but 30 to 100 feet below the surface.

GENERAL GEOLOGY.

The formations exposed in these mountains, from the oldest to the youngest, include: Cambrian sedimentary rocks, post-Jurassic granite and gray quartz-monzonite porphyry, white quartz-monzonite porphyry, diorite porphyry, andesite, older rhyolite and dacite, Siebert lake beds, younger rhyolite, and basalt.

SEDIMENTARY ROCKS.

Cambrian.—The dominant rocks of these mountains are limestones, shales, and quartzites, in part at least of Cambrian age, and in the series no break in the process of sedimentation is apparent. West of Montezuma Peak these rocks consist of 1,000 feet of limestone with some shale beds near its top, overlain by 1,000 to 1,200 feet of shale with some interbedded limestone layers. A bed of white quartzite of fine to medium grain, 40 feet thick, occurs near the middle of the upper shale member. Neither bottom nor top of this series is exposed. Quartzite is more prominent in the hills southwest of Alkali Spring, where it is as abundant as shale.

The limestone is dark gray, compact, and fine grained. The weathered rock is medium gray in color, except in mineralized portions, where the reds, yellows, and browns of iron stains are characteristic. Much of it is siliceous and grades into a black, dense secondary jasperoid of conchoidal fracture. The limestone is massively bedded, except where interlaminated with shale, where it is usually in rather thin beds. Gray lenses and nodules of flint form one-third of the limestone mass 6 miles north of west of Montezuma Peak. By the addition of clay the limestone passes into calcareous shale and finally into shale.

The thin-bedded slaty shales are of fine, even grain and of gray or olive-green color. In many places muscovite plates are present upon bedding planes, and semischistose facies are developed by further formation of muscovite. Where joint planes are closely spaced the shale breaks into pencil-like fragments. Locally weathered surfaces are stained red or brown by iron compounds. With increase in size of grain and in content of quartz the shales pass into dense argillaceous quartzites of greenish-gray to black color and fine to medium grain. Cross-bedding is in places well developed.

The character of the rocks and the series of alternations of various rocks across the bedding planes indicate that the Cambrian rocks were laid down in comparatively shallow water in which conditions favoring mechanical sedimentation on the one hand and organic and perhaps chemical sedimentation on the other hand alternated.

Spurr[a] found fossils southwest of Lida which were determined by Mr. C. D. Walcott to be of Lower Cambrian age. The limestone 4 miles west-northwest of Montezuma Peak contains closely concentrically laminated balls averaging one-half inch in diameter. Mr. E. O. Ulrich states that these resemble *Girvanella*, a calcareous alga, and are probably of Cambrian age. On the evidence of these fossils and the resemblance of the series to that at Cuprite the rocks are believed to be, in the main at least, of Lower Cambrian age. Turner[b] maps Ordovician rocks at one place near the border of the Silver Peak quadrangle, but such rocks, if they exist, were not differentiated during the present reconnaissance.

Siebert lake beds.—Prior to the deposition of the Siebert lake beds the Cambrian rocks had a rugged topography. These beds, 17 miles north of Lida, are coarsely conglomeratic and inliers of limestone protrude through them and outliers of lake beds occur on the Cambrian rocks. The lake beds cover a considerable area on the western border of the region under consideration, a somewhat smaller area near Montezuma Peak, and a small area 5 miles south of Alkali Spring. The northern boundary of the largest area is approximately correct as mapped. The southern boundary is less accurately drawn and some Tertiary igneous rocks may lie between the Cambrian rocks and the lake beds.

These beds, which are composed largely of rhyolitic material, consist of typically incoherent, unevenly granular, well-bedded sandstones. When unstained by iron, they are white in color, but brilliant reds and yellows are characteristic of many areas. Fine-grained beds alternate with conglomeratic layers containing pebbles of Cambrian rocks, quartz-monzonite porphyry, diorite porphyry, rhyolite, and igneous rocks of andesitic and basaltic affinities. The pebbles are well rounded or semiangular. Microscopic examination of several slides shows the presence of quartz and orthoclase crystals in a pyroclastic matrix.

Locally the Siebert lake beds have been indurated by silicification along joints and in irregular bodies. Quartz, chalcedony, and opal fill cavities. The silicified portions weather into wall-like masses along joints and into grotesque topographic forms where silicification has been less regular.

Rhyolitic and dacitic flows are interbedded throughout the sediments, although they increase toward the bottom of the formation and dacite appears to underlie it.

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[a] Turner, H. W., Silver Peak folio; unpublished.

[b] Spurr, J. E., Bull. U. S. Geol. Survey No. 208, 1903, p. 186.

The lake beds at Montezuma Peak are about 1,100 feet thick. On the western border of the area mapped they are probably 200 or 300 feet thicker. The formation was for the most part deposited in an inland lake, although some portions were possibly laid down subaerially by explosive volcanic action.

Mr. R. H. Chapman found a piece of silicified wood at a point 4 miles west of Montezuma Peak. Mr. F. H. Knowlton, who kindly examined it, states that it is wood of a deciduous tree not older than the Tertiary. These sandstones are correlated with the Siebert lake beds of Tonopah, described by Spurr.[a]

Travertine.—A small area of travertine at Alkali Spring, presumably of Pleistocene age, has already been described (p. 35).

IGNEOUS ROCKS.

Post-Jurassic granite, granite porphyry, and quartz-monzonite porphyry.—The dikes and small irregular intrusive masses of white fine-grained alaskite and granite porphyry 2 miles southwest of Alkali Spring are usually injected parallel to the bedding of the upturned Cambrian rocks, but here and there cut across it. The porphyritic habit is better developed at the contact and next to the border phenocrysts are in flow orientation. The rock breaks down into angular joint blocks, many of which are stained by limonite. A single thin section under the microscope proves to be a granite porphyry with microgranitic groundmass of quartz and orthoclase. Coronæ of micropegmatitic quartz and orthoclase surround the abundant phenocrysts of dominant quartz and orthoclase and subordinate biotite and plagioclase (oligoclase). Some phenocrysts are composed of quartz and feldspar in a graphic-granite intergrowth. The phenocrysts all show undulatory extinction, and in consequence the rock has suffered some deformation. Biotite has been completely altered to muscovite shreds, rutile and an iron ore forming simultaneously.

The dikes on the east slope of this hill are composed of medium-grained gray biotite granite. On weathering the granite breaks down into spheroidal masses. It includes numerous small Cambrian fragments, while basic segregations of biotite and probably hornblende are present. This rock proves on microscopic examination to have a granular, hypidiomorphic texture, plagioclase individuals being of columnar habit. The orthoclase, much of which is microperthitic, is usually twinned according to the Carlsbad law. The feldspars are partially replaced by kaolin and sericite and the biotite by chlorite. Zircon and magnetite are accessories. Fine-grained pink aplitic dikes, from 1 inch to 4 inches wide, cut the granite and locally fault the Cambrian inclusions. These more acidic dikes are probably genetically related to the main granitic intrusion.

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[a] Spurr, J. E., Prof. Paper U. S. Geol. Survey No. 42, 1905, pp. 51–55.

Dikes in the Cambrian rocks, 6 miles west of south of Alkali Spring, are composed of a dense white granite porphyry with rather numerous small phenocrysts. These dikes are too small to show on a map of the scale employed in this report. Under the microscope the groundmass appears as a mosaic of quartz and orthoclase which are in micropegmatitic intergrowth over small areas. A little plagioclase is also present. The phenocrysts include orthoclase, usually microperthitic, quartz deeply embayed, and plagioclase. In some specimens rutile rods are so grouped as to simulate somewhat rudely biotite crystals, and it may be that biotite phenocrysts present in the magma were absorbed prior to its solidification. Magnetite is an accessory.

The mass of quartz-monzonite porphyry 4 miles west of south of Alkali Spring and the dikes extending from it into the Cambrian rocks to the northeast are composed of a gray rock of porphyritic habit in which numerous medium-sized phenocrysts lie in a finely granular groundmass. The constituents in the order of their abundance are feldspar, both striated and unstriated, biotite, and hornblende. The rock weathers into rounded blocks. Inclusions of Cambrian rocks are common, as are basic segregations. Microscopic examination shows a microgranitic groundmass, composed of plagioclase laths, orthoclase tablets, and quartz grains. The phenocrysts consist of plagioclase; orthoclase, much of which shows excellent zonal growths; ragged biotite tablets, and hornblende columns. Magnetite and apatite are accessory minerals. The quartz-monzonite porphyry is cut by dikes of diorite porphyry and white quartz-monzonite porphyry. It is believed that this rock is a variant of the granitic magma intruded contemporaneously with the granites of the vicinity.

The Cambrian limestone in contact with the quartz-monzonite porphyry just described has been metamorphosed to a white, medium-grained marble in which epidote and other lime silicates are developed. The shales near the granitic rocks 2 miles southwest of Alkali Spring have been metamorphosed to slates. A dense, greenish-gray slate shows under the microscope as a mosaic of quartz and orthoclase in which are shreds of sericite and chlorite. Locally the sericite and chlorite form large skeleton growths containing numerous quartz and feldspar individuals. Another facies is a dense, black slate of conchoidal fracture. In thin section this is formed of large, rounded areas of orthoclase lying in a ramifying network of orthoclase grains intimately cut by biotite and muscovite shreds. Imperfect andalusite crystals are scattered throughout the rock, and some of these have the black centers characteristic of the variety called chiastolite.

These igneous rocks intrude Cambrian rocks and occur as pebbles in the rhyolite and Siebert lake beds. They are believed to be members of the post-Jurassic granite series.

White quartz-monzonite porphyry.—In the vicinity of Lida dikes and fewer sheets of white quartz-monzonite porphyry are common. The three areas shown on the map include both sheets and complex intrusive masses filled with inclusions of Cambrian rocks, while many other areas are too small to be mapped on the scale employed here. The dike which cuts the gray quartz-monzonite porphyry 4 miles west of south of Alkali Spring has already been mentioned.

This quartz-monzonite porphyry is a dense, white or locally greenish rock, with rather abundant medium-sized phenocrysts, consisting of somewhat altered whitish feldspars, some striated and others unstriated, silvery mica, and rarely a quartz crystal. The central portions of the dikes and intrusive masses are more coarsely crystalline than the borders, and in certain instances approach a granitoid texture.

The rocks break into sharp joint blocks, which in many places are stained by limonite. Limestone in the vicinity of this rock is here and there silicified and indurated, although the metamorphism is slight.

Microscopic examination proves the medium-grained microgranitic groundmass to consist of orthoclase grains, plagioclase laths, and a few quartz anhedra. The phenocrysts of orthoclase slightly predominate over those of plagioclase (oligoclase-andesine). Kaolin and sericite are the alteration products. Biotite phenocrysts altered to muscovite or chlorite, with an iron ore and rutile in rods or sagenitic webs, are constantly present, while quartz phenocrysts, much corroded, appear in some thin sections.

The white quartz-monzonite porphyry is younger than the granite which it cuts in the area 4 miles west of south of Alkali Spring. Pebbles of the porphyry are included in the Siebert lake beds. It is believed that it is genetically related to the granite and is a later intrusion of the same magma.

Diorite porphyry.—Dikes of quartz-diorite porphyry cut the gray quartz-monzonite porphyry 4 miles west of south of Alkali Spring, and many dikes of diorite porphyry, probably of contemporaneous age, intrude Cambrian rocks near Lida. The quartz-diorite porphyry is a dark, rather fine-grained holocrystalline rock. Under the microscope the presence of biotite is revealed. Ophitic texture is well developed, plagioclase laths (some andesine and more basic) lying in a mesostasis of hornblende, biotite, and a little quartz. The rock weathers into sharply jointed blocks of dark color. The diorite porphyry is a greenish-gray rock of porphyritic habit, both hornblende and striated feldspars occurring as phenocrysts. Epidote is developed in the rock and forms crystalline felts along joint planes. Spheroidal weathering is characteristic.

The contact of the white quartz-monzonite porphyry and the diorite porphyry is poorly exposed 1 mile northeast of Lida, and the latter rock is apparently younger than the former. Pebbles of the diorite porphyry occur in the Siebert lake beds—a fact which leads to the belief that these dikes were intruded in post-Jurassic and pre-Miocene time.

Andesite.—The andesite masses 4 miles north of Lida were seen by the writer only at a distance, but Turner,[a] who mapped their western extension, believes the andesite to be of "early Neocene" age, and it is probably older than the formation described in the following paragraphs.

Rhyolites and dacites.—Thin flows of rhyolite are interbedded with the lower portions of the Siebert lake beds of Montezuma Peak and of the area 4 miles north of it. The lake beds seem to lie on a siliceous effusive igneous rock which forms a narrow north-south band to the east of Montezuma Peak. Small areas of rhyolite are exposed by the erosion of the overlying basalt mesa 3½ miles east and 4 and 5 miles southeast of Montezuma Peak. A small poorly exposed mass of rhyolite—possibly a dike, to judge from the disturbed condition of the surrounding limestone—lies 5 miles north of west of Montezuma Peak. Rhyolite is also exposed 3½ miles north of Lida.

The rhyolite flows in the Siebert lake beds are dense gray or pink rocks, in which are sparse and small phenocrysts of quartz, orthoclase, and biotite. Black glasses are also present. Flow banding is highly developed, and spherulites form freely in cavities and impinge against one another in the more dense facies. The spherulites, some of which are simple and others compound, are of radial structure. The larger ones are 2 inches in diameter. Lithophysæ occur in the area 4 miles north of Montezuma Peak. Under the microscope the glassy groundmass appears somewhat devitrified. The flows here contain numerous pebbles of Cambrian jasperoid and quartz-monzonite porphyry.

The siliceous eruptive rock east of the Siebert lake beds of Montezuma Peak is a red semivitreous rock in which some small phenocrysts of striated feldspar and fewer of unstriated feldspar and quartz are sparsely distributed. The microscope shows numerous plagioclase microlites in the glassy groundmass, and orthoclase is so subordinate that the rock is a siliceous dacite.

The rhyolite of the other areas mentioned has abundant phenocrysts of quartz, orthoclase, and biotite in a light-colored groundmass which under the microscope appears as a glass somewhat devitrified, showing flow banding and spherulites. In one slide a few plagioclase phenocrysts are present with those already mentioned. Zircon and magnetite are accessories. This rhyolite grades into a white waxy glass without phenocrysts in the area 4 miles east of Montezuma Peak.

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[a] Turner, H. W., Silver Peak folio; unpublished.

The siliceous igneous rocks are probably all portions of a single series that is older, for the most part, than the Siebert lake beds. They are probably contemporaneous with the Tonopah rhyolite-dacite described by Spurr[a] as presumably of Miocene age.

Later rhyolite.—Lying upon the eroded surface of the Cambrian rocks and protruding from the Recent alluvial deposits in the vicinity of Alkali Spring are small exposures of a lavender lithoidal igneous rock, with fairly numerous glassy feldspar phenocrysts of medium size. These rocks closely resemble the later rhyolite underlying the basalt flows at Goldfield and are tentatively correlated with it.

Basalt.—A basalt mesa lies between the spurs of the Silver Peak Range and the Goldfield hills. For convenience its description is given with that of the hill group (p. 75). A basalt dike 50 feet wide cuts the Cambrian limestone near its contact with the Siebert lake beds on the Montezuma-Goldfield road. The basalt is a dense black rock containing medium-sized glassy olivine grains and small striated feldspars and black augites. Under the microscope the rock is seen to be a holocrystalline olivine basalt. The plagioclase is partially altered to calcite and the olivine to serpentine. Basalt also covers a considerable area 1½ miles southeast of Lida. This is evidently a flow, the red or black rock being full of vesicles and much of it having a ropy surface. This rock is contemporaneous with the basalt of Mount Jackson and Goldfield, and the dike near Montezuma is probably of the same age.

Five miles northeast of Lida a flow of andesite or basalt lies upon the eroded surface of the Cambrian limestone. It has a gray lithoidal groundmass in which large striated feldspar phenocrysts are prominent. Lithologically the rock resembles certain members of the basalt flow south of Goldfield, but the mature topographic form of its surface may more nearly ally it to the older andesite already described.

STRUCTURE.

The Cambrian rocks are for the most part in rather open folds with north or northeast axes, which are crossed by minor folds. The amount of dip as a rule is not great, although at many points in the isolated hill southwest of Alkali Spring the rocks are on edge and the folding appears close. Locally small isoclinal folds are present, particularly near intrusions of granite, and the northwest strike of the Cambrian 5 miles north of Montezuma Peak is probably due to the intrusion of the quartz-monzonite porphyry. The gentle character of the folding of much of the Silver Peak Range is in marked contrast with that of the Amargosa Range and Bare Mountain to the south and southwest. The folding, in part at least, preceded the intrusion of the granite, since this rock is intruded along vertical bedding planes southwest of Alkali Spring. Small faults, usually reverse, are common in the Cambrian rocks, while zones of brecciation in the limestone indicate that differential movement has occurred at many places. The Siebert lake beds are approximately horizontal, although flexures and normal faults occur. The normal north-south fault west of Montezuma Peak has a throw probably amounting to several thousand feet. The uplift of this range since Miocene time has been great, since the Siebert lake beds, once beneath a lake, have been elevated and eroded into mountains.

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[a] Spurr, J. E., Prof. Paper U. S. Geol. Survey No. 42, 1905, pp. 41–43.

ECONOMIC GEOLOGY.

Two mining camps, Montezuma and Lida, are located in this spur of the Silver Peak Range.

MONTEZUMA DISTRICT.

The Montezuma mining district was organized in 1867, and soon afterwards several mines were opened in the country west of Montezuma Peak. In 1886 a mill was erected in the gulch to the northwest of the mountain. Active work ceased in 1887, but at present a number of prospectors are reopening old properties and locating new claims. The district product, estimated at $500,000, was freighted in wagons to Belmont, 65 miles away. At present only a few shallow prospect holes and the dumps of the old mines are accessible for examination. The mineralized area lies to the west of Montezuma Peak, in Cambrian rocks.

In the old mines the chief gangue is quartz, with rarely a little calcite and kaolinitic material. Vugs filled with quartz crystals occur in the quartz. The ores at the surface are cerussite, malachite, azurite, manganese dioxide, and limonite, and associated with these and replacing them in depth are galena, chalcocite, and pyrite. The values are largely in silver, the gold values being uniformly low. Chlorobromides of silver are reported, but were not seen.

A prospect hole exposes a quartz vein having white quartz-monzonite porphyry as the hanging wall and limestone as the foot wall. Chalcopyrite is the original sulphide, and malachite with less limonite, azurite, and a little native copper are the secondary ores. The native copper forms thin sheets in cracks and small nodules in the vein. Malachite partially replacing limestone was noted at a number of other places.

At Montezuma copper and lead sulphides with quartz fill open fissures in limestone. Some, probably all, of the deposition followed the pre-Tertiary dike injection. Later the veins were crushed, and surface waters altered the sulphides to carbonates, oxides, native metals, and probably haloid salts. This chemical breakdown of the sulphides continues to the present day, as is shown by the fact that the water flowing from an abandoned tunnel southwest of the mill at Montezuma deposits considerable limonite and is so charged with ferrous sulphate that animals will scarcely drink it.

In several of the older mines and prospects water, both good and bad, was encountered at a depth of 30 feet. The mines will probably require pumps, but abundant fuel surrounds them. Goldfield, the railroad terminus, is 9 miles distant, the road being fairly good.

LIDA.

The Lida mining district was organized August 28, 1871, and in the succeeding decade some rich surface pockets of horn silver and silver-bearing galena were removed. The ore, probably picked, ran from $500 to $1,000 per ton. It is said that the values decreased at depths of 200 to 300 feet. In the latter part of 1904 and the early part of 1905, the attention of mining men having been turned to southwestern Nevada, old mines were reopened and new locations made. Unfortunately, at the time of the writer's visit (December, 1905), the principal prospects were closed through litigation, and in many cases pumps and ladders had been removed. The prospects are situated partly outside the area surveyed and partly on the east slope of Mount Macgruder to the south and southeast of the village.

The Florida-Goldfield Mining Company's shaft is near the mouth of a gulch which joins the Lida Valley about one-half mile below the village. When visited, the shaft, 150 feet deep, was filled with water within 80 feet of the surface. The ore on the dump includes Cambrian limestone rather heavily impregnated with iron pyrites and pyrite inclosed in veins of coarsely crystalline white calcite and in white quartz veinlets. In some specimens galena and light-brown zinc blende are associated with the quartz veinlets carrying pyrite. Chalcopyrite, an apparently still more uncommon sulphide, is in places superficially altered to malachite and azurite. The limestone cut by the quartz vein has been more or less silicified. An old open cut above this shaft shows a zone of brecciated limestone 4 feet in width healed by innumerable connecting quartz veinlets in which the ores mentioned occur. On the dump of the Thanksgiving mine quartz masses and veinlets cutting similar limestone were examined. The quartz contains much pyrite and less chalcopyrite.

The sulphides of the Lida deposits are in part fissure fillings and in part impregnations of the country rock, while the oxidized ores appear to be largely replacements of limestone. The oxidized zone is, for a desert country, very shallow.

In the early days of mining in this district considerable bunches of oxidized ore were hauled to Austin and Belmont. It is scarcely probable that all these pockets have been found, and with the improved transportation facilities such deposits should pay well.

Some of the ore mined from the newly located prospects is reported to run from $100 to $500 per ton in gold and silver. Such assay returns, however, in at least the majority of cases, were obtained from picked samples and are of no value in estimating the economic possibilities of a prospect. The water level, to judge from the development work so far carried on in the Lida district, is comparatively near the surface. Much of the ore already taken out is refractory and would require milling and smelting. In this respect the Lida district is at a disadvantage in comparison with the surrounding districts, but on the hills surrounding the mines there is a fair growth of piñon and juniper, which will furnish, for a time at least, satisfactory fuel and some mining timber. Water, sufficient for mining and domestic purposes, flows from springs in and above the village and can be obtained in the Lida Valley at slight depths. A daily stage runs from Lida to the railroad at Goldfield.

OTHER MINERALIZED AREAS.

Quartz veinlets are abundant in the Cambrian quartzite and shale and are locally present in the limestone, although calcite veins are more characteristic of the limestone. The quartz and calcite veins were evidently formed at several periods, since in many places one set faults another and in turn has itself been faulted. Strong quartz veins occur in limestone heavily stained by limonite and hematite 5 miles north of west of Montezuma Peak. Quartz veins also occur in the limestone area 6 miles north of Montezuma Peak. Thin sheets of malachite replace limestone along joint planes 3 miles north of Montezuma Peak.

LIME.

A kiln 2½ miles west of south of Montezuma Peak burns Cambrian limestone. The lime, which is sold in Goldfield, is reported to be of good quality.

LIDA-GOLDFIELD VALLEY.

The Lida-Goldfield Valley lies between Mount Jackson and the Goldfield hills on one side and the Silver Peak Range on the other. A low detrital divide west of Mount Jackson separates it from the valley north of Slate Ridge. The lowest part of the valley lies at an elevation of 5,100 feet, and from a distance appears to be occupied by two small playas. On the east side of the valley, north of Mount Jackson, some intensely dissected hills, 50 to 150 feet above the valley bottom, appear at a distance to be formed of playa deposits of the older alluvium. It is also possible that the apparent playas are in reality eroded exposures of the same formation.

MOUNT JACKSON AND THE HILLS TO THE NORTHEAST.

TOPOGRAPHY AND GEOGRAPHY.

Mount Jackson is a prominent butte which rises 800 feet above its alluvial base. Northeastward from it extends a ridge on which are superimposed buttes of the Mount Jackson type, capped by resistant lava flows. At its north end this ridge is divided by a valley into two parts. These hills are separated from the Goldfield hills to the north by basalt lava flows. For convenience the mesa-capped hill east of Cuprite and the isolated hills 10 miles east of north of Mount Jackson will be described here.

Water is unknown in these hills, and with the exception of scattered groves of the tree yucca they are bare. Grass is fairly abundant on the upper portions of the encircling alluvial slopes.

GENERAL GEOLOGY.

The formations exposed in these hills, named from the base upward, are Cambrian sedimentary rocks, diorite porphyry, Siebert lake beds, rhyolite, and basalt.

SEDIMENTARY ROCKS.

Cambrian.—An area in the southern ridge and another at the north end of the northern ridge are occupied by Cambrian sedimentary rocks, and the same rocks also in part form the isolated hills in the valley traversed by the Goldfield-Lida road.

A compact fine-grained black or dark-gray limestone, locally silicified to a black jasperoid of conchoidal fracture, is the dominant member of the Cambrian series. Both rocks are intricately cut by white calcite veinlets. Layers of thin-bedded green slaty shale, in places schistose, are interbedded with the limestone, as are smaller amounts of white medium-grained quartzite. A total thickness of 3,000 to 3,500 feet of Cambrian rock is exposed. These sediments form gentle hills elongated in the direction of strike, the shales being characterized by few, the limestone and quartzite by many exposures.

Mr. E. O. Ulrich determined the following fossils collected by the writer near the Goldfield-Midway-Bullfrog mining camp, 2 miles south of west of Cuprite: *Olenellus*, near *O. gilberti; Hyolithes*, closely related to or identical with *H. americanus;* undetermined orthoid shell.

He states: "So far as this imperfect material will permit of determining age, it points to a Lower Cambrian horizon." *Girvanella*-like forms similar to those from the Silver Peak Range were also found in these Cambrian rocks. The Lower Cambrian age of portions of the series is thus demonstrated, although other portions may be somewhat younger. The rocks are correlated with those of the north spur of the Silver Peak Range and of the Lone Mountain foothills, *Siebert lake beds.*—White, finely bedded tuffaceous sandstones and clays, 200 to 300 feet thick, underlie the rhyolite of Mount Jackson and that of the isolated butte 10 miles east of north of it. Small areas of the same formation, not shown on the map, occur with the rhyolite northeast of Mount Jackson. Rhyolite pebbles occur in these sediments. At the more northerly butte they contain also thin rhyolite flows and lie unconformably upon the folded Cambrian rocks, which were evidently low hillocks in the lake bottom on which the sandstones were deposited. On lithologic and structural grounds these sandstones are correlated with the Siebert lake tuffs at Tonopah, described by Spurr.[a]

IGNEOUS ROCKS.

Diorite porphyry.—A dike of dark greenish-gray diorite porphyry cuts the Cambrian limestone one-fifth of a mile northwest of the Goldfield-Midway-Bullfrog mining camp already mentioned. The dike is 20 feet wide and courses N. 35° E. The dike rock, much altered, weathers into iron-stained spheroidal masses. The limestone at the contact is slightly indurated, approaching a hornfels. Macroscopically this dike rock resembles pre-Tertiary diorite prophyry of the Silver Peak Range.

Rhyolite.—Rhyolite flows cover a large portion of these hills. The rhyolite contains small and scarce phenocrysts of quartz, glassy feldspar, and biotite, which however, in some facies are lacking. The groundmass ranges from pumiceous to compact glasses of conchoidal fracture and varies in color from white through gray to black. Perlitic cracks traverse the glass in all directions and reddish-brown spherulites are common. The smaller spherulites show both radiate and concentric structure, while the larger, which reach a diameter of 8 inches, are traversed by fine wavy lines parallel to a diameter, although they break into sectors of a sphere. Some of the spherulites are simple, although as a rule two or more are linked together. .Chalcedony is abundantly developed in joint cracks.. Thin sections under the microscope show spherulites, cavities filled with gas, perlitic cracks which may extend through the phenocrysts, flow lines, and other phenomena typical of rhyolites.

The flow beds are from 2 inches to 50 feet thick, the upper surface being in some instances corrugated like the ropy surface of basalt flows. The maximum determined thickness of the rhyolite flows is 400 feet, although the total thickness may be somewhat greater. Small isoclinal folds were formed during the outflow of the lava, which must have been rather viscous and which on meeting an obstruction was crumpled. In one case a glassy facies folded with thin bands of semiglassy phenocryst-bearing rhyolite exhibits interesting features. (See fig. 5.) The more crystalline rhyolite was sheared and fractured along the limbs of the fold, while the glassy facies thickened at the troughs and crests. The thinner flows weather somewhat like a horizontal sedimentary rock, while the thicker show the rounded topographic forms of granite.

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[a] Spurr, J. E., Prof. Paper U. S. Geol. Survey No. 42, 1905, pp. 51–55.

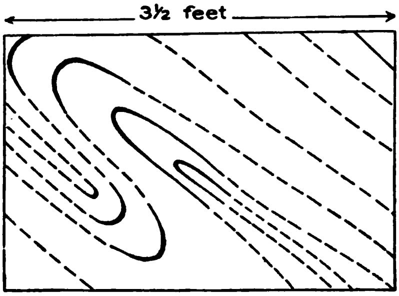

FIG. 5.—Flow folds in rhyolite (hill 10 miles east of north of Mount Jackson), showing thickening of more glassy rhyolite (white) on crests and troughs of folds and cross fractures in more lithoidal rhyolite on limbs of folds.

Minor rhyolitic effusions started while the Siebert lake beds were being deposited, although the major outflow was later. The rhyolite is probably to be correlated with the younger rhyolite of the Amargosa Range and is of late Miocene or early Pliocene age.

Basalt.—Slightly eroded benches of basalt flank Mount Jackson on the south and a small basalt area is located 5 miles to the east. The basalt is a dense black vesicular flow rock which microscopic examination proves to be an ordinary olivine basalt. As Spurr states,[a] erosion carved Mount Jackson approximately to its present form prior to the outflow of basalt. At the north end of the ridge east of Cuprite and in several small areas west of the Goldfield-Bullfrog road is basalt which is an extension of the younger basalt of the Goldfield hills. (See p. 75.) It is probable that small areas of younger rhyolite and late tuffs of these hills are here mapped with the basalt. The basalt northeast of Cuprite clearly overlies and is younger than the rhyolite, being probably of late Pliocene or early Pleistocene age.

STRUCTURE.

The Cambrian rocks are in rather open folds of northeast-southwest axes (fig. 6). The angle of dip rarely exceeds 30°, although 4 miles west of Cuprite isoclinal folds occur. The highest hills of the two main ridges are situated on the axes of synclines. The rocks on the south face of the hills toward the valley north of Slate Ridge dip gently to the west. Faults, usually normal and across the strike

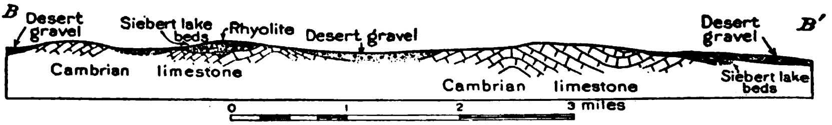

FIG. 6.—East-west section across Mount Jackson hills 1 mile south of Halfway Station.

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[a] Spurr, J. E., Bull. U. S. Geol. Survey No. 208. 1903, p. 183.

of the rocks, occur but do not seem to be of large throw. The Siebert lake beds and the later lavas are practically horizontal, their elevation being attended only by minor flexing and faulting.

ECONOMIC GEOLOGY.

The prospects of the Cuprite mining district, in which the first locations were made early in 1905, lie in a belt 1 mile wide which extends from a point 17 miles south of Goldfield westward to Mount Jackson. The mines are from 2 to 9 miles west of the stage and automobile road between Goldfield and Bullfrog.

The properties of the Goldfield-Midway-Bullfrog Mining Company and the Tri-Metallic Mining Company may be taken as types of the Cuprite mining district. The Copper Bell shaft of the first-named company, 85 feet deep, is located on the side of a gentle valley in Cambrian sedimentary rocks 2 miles south of west of Cuprite. The shaft is being sunk to encounter a vein which strikes N. 60° E. and dips from 80° to 85° NW. This vein has been traced by means of prospect holes at least 1,000 feet. At one prospect hole the vein is capped by a gossan of spongy limonite 9 feet thick. At this depth malachite and less azurite are associated with the limonite and at the bottom of the hole, 9 feet deeper, the vein is reported to have run 12 per cent copper, with 14 ounces of silver and $1.20 in gold per ton. The vein is from 2 to 5 feet wide and on its borders shows a gradual passage from totally unaltered limestone to pure limonite. The limonite, on the border of the vein at least, is a replacement of the limestone. The same company has an incline 65 feet deep situated on a shear zone which strikes N. 85° E. and dips 60° S., cutting practically horizontal limestone. A streak of ore 1½ to 2½ feet wide, traceable more or less continuously for 900 feet, occupies the shear zone. The ore consists of malachite, azurite, and limonite associated with heavily limonite-stained chalcedony of conchoidal fracture. The sulphides are chalcocite and less chalcopyrite and pyrite. The two latter are undoubtedly original. A number of assays of the ore are said to have averaged between 9 and 10 per cent of copper, while the silver values are variable, reaching as high as 400 ounces per ton. Evidently the silver is intimately associated with the copper minerals, the iron compounds giving no silver returns. The average ore runs about 1 ounce of silver per ton to 1 per cent of copper, while gold is present in traces only. Another prospect on this property is in limestone much stained by limonite. Malachite and less azurite, with an intensely limonite-stained chalcedonic quartz, occur in small kidneys throughout the limestone and in narrow seams along joint planes. Chalcopyrite is reported from the surface here, but is not abundant. In another prospect irregular lenses of the same ores and gangues lie in a narrow shear zone in the limestone. Small bunches of chalcopyrite are sporadically distributed in the dark chalcedony.

The property of the Tri-Metallic Mining Company lies one-half mile west of that last described. The Cambrian limestone, although gently flexed, is approximately horizontal. Intense staining by limonite is characteristic of limestone in the vicinity of the ore. A shipment of picked ore which netted $236 per ton (averaging 7 ounces gold, 230 ounces silver, and 19 per cent copper) was recently made from a surface pocket of ore. Chalcopyrite is the only original sulphide present. Chalcocite, malachite, and azurite with dark-brown chalcedony are secondary, and these are partially at least replacements of limestone. A few masses of native copper, presumably of secondary origin, are also reported, but they were not seen by the writer. Apparently chalcopyrite was originally distributed in the limestone in masses which, so far as known, do not exceed one-half inch in diameter. Later these scattered particles were concentrated, the secondary copper minerals apparently being replacements of limestone. In the main shaft bunches of chalcopyrite lie in the limestone in association with coarse calcite much stained by limonite. In some cases the chalcopyrite has been brecciated and the narrow interstices filled with iron-stained chalcedony. The ore in this shaft is said to have been in "kidneys," some of which were connected with others by narrow seams. From one of these masses 1,900 pounds of ore were removed. This lens of ore, 9 feet long, was 4 feet in diameter at the center and tapered to a point at each end.

Ore examined from a claim owned by E. Oldt showed similar characteristics, a little galena and white quartz of apparently equal age being associated with the sulphides. Transparent drusy quartz crystals contemporaneous with or later than the copper and lead carbonates and brown chalcedony are also characteristic. The values in this ore are said to be in silver and copper.

In the Cuprite district chalcopyrite and less pyrite, galena, calcite, and quartz appear to have been deposited as sporadic masses in the limestone as seams along joints and as lens-shaped bodies along shear zones. Later these ores were altered by aqueous solutions to chalcocite, carbonates, and oxides, the secondary ores in large part replacing limestone. At many points faulting accompanied or preceded the change. Contemporaneously a much iron-stained chalcedony was deposited in intimate association with the oxidized ores. Later, in some instances, drusy quartz was deposited upon the copper carbonates. The development is altogether too slight to determine what part of the secondary copper ores have been concentrated from sulphides originally lying in limestone now removed by erosion. It is probable, however, that a considerable proportion is of such origin and that when the oxidized ores are worked out the copper content will decrease. It may well be, however, that the water level at Cuprite is deep.

In the rhyolite north of the east end of the copper belt are some prospects. The values reported are gold, and these deposits are undoubtedly late Tertiary veins.

Water is hauled from Stonewall Spring, 17 miles distant. Wood, except the almost valueless yucca, is equally distant. The Cuprite mines, however, are only 18 to 25 miles from the railroad at Goldfield, and ore may be shipped from the district at a comparatively low cost.

Sulphur of good quality, said to occur in a vein in the rhyolite about three-fourths of a mile northeast of Cuprite, was examined.

VALLEY NORTH OF SLATE RIDGE.

The valley north of Slate Ridge is connected by two narrow arms of gravels with Sarcobatus Flat and by a single similar arm with Stonewall Flat. The valley has an east-west extension and is of moderate grade. Playas are situated in its eastern portion at elevations between 4,500 and 4,600 feet above sea level. Buttes of late Tertiary lavas are scattered over the lower portions of the valley. South of Mount Jackson a number of low white domes and dissected mesas of the older alluvium protrude from the Recent gravels, and the position of the more important of these is shown on the map. The exposures, where examined, consist of stratified clay beds lying horizontally. The area immediately south of Mount Jackson is 300 feet above the lowest deposits in the valley, and this may be taken as the minimum thickness of the formation, which is evidently a playa deposit of the older alluvium. The Recent gravels are probably thin throughout the valley. Some water lies most of the year in a tank at Forks Station.

GOLDFIELD HILLS.[a]

TOPOGRAPHY AND GEOGRAPHY.

The Goldfield hills are separated from the northeastern spur of the Silver Peak Range and the Mount Jackson hills by low mesas of basalt and from the Southern Klondike hills and the Cactus Range by low ridges of desert gravels. Most of the low hills and ridges around Goldfield have a north-south trend, but some run east and west. The highest summits are less than 7,000 feet above sea level. Except for the usual desert shrubbery the Goldfield hills are bare. Several springs occur in the eastern portion of the hills, and a spring is located near Goldfield. Wells at Goldfield, in the Siebert lake beds, have struck water, but the main water supply is piped from distant points.

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[a] The ore deposits and geology of the Goldfield special area have already been described by Mr. F. L. Ransomé (Bull. U. S. Geol. Survey No. 303). The map made by Mr. Ransome and his assistants, Messrs. G. H. Garrey and Wm. H. Emmons, has been generalized and incorporated in Pl. 1, and the writer is indebted to these gentlemen for many suggestions as to the stratigraphy in these hills. The description here given applies mainly to the Goldfield hills beyond the area shown on the special map. The geology of these outer hills was studied practically without a topographic base, a fact in part accounting for the shortcomings of the map.

GENERAL GEOLOGY.

In the detailed survey of the special area Mr. Ransome and his assistants recognize the following formations, named from the oldest to the youngest: Cambrian (?) jasperoid; post-Jurassic granite; first andesite; earlier rhyolite; andesite and dacite, the latter formation probably being slightly younger; quartz latite and rhyolite; Siebert lake beds, with associated quartz-basalt and rhyolite flows; later rhyolite; later tuffs, and basalt.

Of these formations the Cambrian jasperoid and the first andesite and rhyolite appear to be confined to the special area and are described in another bulletin of the Survey.[a] The rhyolite flow breccia occurs only in thin flows and, because of the small scale employed, is mapped with the basalt.

SEDIMENTARY ROCKS.

Siebert lake beds.—The Siebert lake beds cover considerable areas in the central and southern portions of the Goldfield hills and form a band between the basalt and the Recent desert gravels. The actual distribution of the formation is greater than that shown on the map, since small areas lie on the eroded surfaces of the andesite and the latite and rhyolite in many places. These lake beds are gray, yellow, or reddish sandstones, shales, grits, and conglomerates, composed predominantly of material derived from the Tertiary lava flows, but subordinately of Paleozoic sedimentary rocks and post-Jurassic granular igneous rocks. The larger bowlders are 2 feet in diameter. Sections on the mesa scarp, in which the base is not exposed, show a vertical exposure of 240 feet. The Siebert lake beds were folded and the edges of the beds truncated by erosion prior to the outflow of the later rhyolite. The formation closely resembles the Siebert lake beds of Tonopah[b] and is presumably of Miocene age.

Later tuffs.—On the mesa scarp to the west and northwest of Goldfield 10 to 20 feet of tuffaceous sandstone lie above the later rhyolite and beneath the basalt. These sediments, probably deposited under water, are characterized by many bowlders of a silvery-gray pumice, presumably derived from the erosion of the surface of the underlying rhyolite. The position of these tuffs beneath the basalt with no marked erosional interval indicates that they are probably to be correlated roughly with the lower portion of the Pliocene-Pleistocene older alluvium occurring elsewhere in the area studied, although they were probably deposited in a lake, the predecessor of the older playas.

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[a] Ransome, F. L., Preliminary account of Goldfield, Bullfrog, and other mining districts in southern Nevada, etc.: Bull. U. S. Geol. Survey No 303, 1907, 98 pp., 5 pls.

[b] Spurr, J. E., Prof. Paper U. S. Geol. Survey No. 42, 1905, p. 51.

IGNEOUS ROCKS.

Post-Jurassic granite.—In addition to the granite mapped by Ransome in the special area, pebbles of alaskite and a somewhat less siliceous rock, probably to be correlated with the darker monzonite porphyry of the northeast spur of the Silver Peak Range, occur in the Siebert lake beds.

Andesite and dacite.—Ransome found that andesite flows and dacite intrusions, the latter probably being slightly younger, followed the extrusion of the earlier rhyolite. These formations have been separated in the detailed study of the Goldfield special area, but since the andesite is by far the more abundant rock, the dacite is here grouped with it. It is the most widely distributed formation in the Goldfield hills and appears from a distance to cover a large area in their northeast portion. The later andesite is a rather dark-gray to light-pinkish rock with dense lithoidal groundmass. Phenocrysts, which equal the groundmass in bulk, consist of feldspar and hornblende, augite, and biotite, one of these latter being present in many cases to the almost total exclusion of the others. The dacite, which covers considerable areas within the district shown on the special map, extends eastward beyond its borders, is usually slightly lighter in color than the andesite and contains a few quartz phenocrysts.

The andesite and dacite are younger than the earlier rhyolite and older than the biotite latite and rhyolite. The later andesite is similar in many ways to the later andesite of Tonopah [a] and the two formations may be roughly contemporaneous. The dacite is correlated with that of the Kawich Range. These rocks are probably of early or middle Miocene age.

Quartz latite and rhyolite.—Several outcrops of quartz latite and rhyolite occur in the hills surrounding the Goldfield special area. While some of these may belong to the earlier rhyolite, the majority should certainly be assigned to the quartz latite and rhyolite. Quartz latite outcrops 2 miles south of Preble Mountain. The rock here has a white stony groundmass, slightly exceeded in bulk by the medium-sized phenocrysts of which black mica is most conspicuous, while glassy feldspar striated or unstriated and slightly smoky quartz also occur. Many small ellipsoidal areas of pumiceous latite are present, indicating that the rock was in part a flow breccia. Under the microscope the quartz latite is seen to have a turbid glassy groundmass, with many eddying flow lines. The larger feldspar phenocrysts are andesine and in total bulk the plagioclase phenocrysts slightly exceed those of orthoclase. Orthoclase in particular is zonally built. Quartz has been greatly and biotite slightly corroded by the magma. The magma must have been very viscous prior to the cessation of movement in it, since the phenocrysts are typically broken fragments. Apatite is an accessory mineral.

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[a] Spurr, J. E., Prof. Paper U. S. Geol. Survey No. 42, 1905, p. 33.

Rhyolitic glasses that outcrop 3 miles south of east of Diamondfield probably belong to the biotite-latite-rhyolite series. These gray perlitic glasses are poor in phenocrysts, although biotite and less commonly feldspar and quartz are locally present. Flow banding is evidenced by slight alterations in the color and texture of various bands. The perlitic glass grades into spherulitic and dense pinkish-gray glassy rhyolites. The perlitic facies breaks readily into globular fragments along the perlitic parting. The clear glass in some thin sections contains sparse phenocrysts of orthoclase, quartz, and biotite, while in others the phenocrysts are more abundant and oligoclase is also present.

The rhyolite in the southeast corner of the Goldfield hills has highly developed flow banding, and in consequence the rock has a platy structure which wraps knotlike around the phenocrysts. Blackish glasses with numerous phenocrysts also occur. Microscopic examination shows this glass to be in reality a latite with phenocrysts of oligoclase, orthoclase, biotite, quartz, and hornblende.

On the east side of the Goldfield-Lida road, 2½ miles south of Goldfield, is a poorly exposed area of rhyolite. The white lithoidal groundmass, much of it brown or red through iron stains, somewhat exceeds in bulk the abundant phenocrysts. The latter include glassy unstriated feldspar, somewhat less quartz, and a few black mica tablets. Fragments of a pumiceous rhyolite are present. Under the microscope the groundmass appears as a turbid, slightly devitrified glass, showing flow lines and spherulites. A few rather large oligoclase phenocrysts are associated with those of orthoclase, quartz, and biotite. The phenocrysts are all somewhat embayed by magmatic corrosion and were broken into fragments during the flow of the nearly viscous lava. This rhyolite probably belongs to the series under consideration, although it may be one of the later rhyolites. One mile farther south a similar rhyolite outcrops, and this clearly belongs with the quartz latite and rhyolite series, since it was a low boss when the mesa basalt was extruded and that formation flowed in a gentle arch over its surface.

The quartz latite and associated rhyolite are older than the Siebert lake beds and younger than the andesite.

Quartz basalt.—The basalt to the east of the Lida road and 2 miles south of Goldfield is probably a portion of the quartz-basalt flow which Ransome found interbedded with the Siebert lake beds in the special area.

Later rhyolite.—Lying for the most part in a horizontal position upon the eroded Siebert lake beds is a rhyolite flow, which is separated from the overlying basalt by the Pliocene tuffs. This formation is too thin to be shown on the map, but it forms a narrow band from 50 to 100 feet thick beneath the basalt capping of the mesa and occurs also to the south of Goldfield in the area here mapped as Siebert lake beds.

The later rhyolite includes a number of facies of acidic flow rocks. On the Goldfield-Bullfrog road, 3 miles east of south of Goldfield, the formation is 50 feet thick and consists of 4 feet of black glass, above which is 20 feet of faded brick-red dense rhyolite and above this 25 feet of lavender lithoidal rhyolite. The black glass has an excellent flow parting. The middle rhyolite carries rather numerous glassy feldspar phenocrysts, which are, however, subordinate in bulk to the groundmass. It contains many vesicles elongated parallel to the flow, and in these spherulites are developed. The spherulites in some instances form shelf-like partitions in the cavities. Vertical columnar parting is fairly well developed in this portion of the flow. Under the microscope the groundmass, which has many eddying flow lines, shows as a slightly devitrified turbid glass. The phenocrysts are orthoclase, with which are associated a few of plagioclase and bluish-green augite. The presence of considerable quartz in the devitrified glass probably justifies the use of the name rhyolite. The upper member is a flow breccia with lithophysæ here and there throughout its mass. The phenocrysts in the glassy base are seen under the microscope to be orthoclase, bluish-green augite, and quartz. A rhyolite similar to the middle member of this section is exposed 1½ miles southwest of the type locality and north of the Goldfield-Cactus Spring road, 1 mile west of the edge of the alluvial slope. Similar rocks occur beneath the basalt of the mesa west of Goldfield. One facies from this mesa is similar to the upper portion of the flow at the type locality, although phenocrysts, particularly quartz, are more abundant. Apatite is also microscopically visible. Such facies locally include fragments of quartz basalt and the Cambrian jasperoid.

The extrusion of this rhyolite occurred after the folding and erosion of the Siebert lake beds. It is presumably of Pliocene age. Similar rocks occur in the Silver Peak Range, in Slate Ridge, and beneath the basalt of Pahute Mesa.

Basalt.—The youngest formation of the Goldfield hills is the basalt which forms the mesa west of Goldfield, with which the basalt to the northwest of Diamondfield is probably contemporaneous. At one time basalt covered the greater portion of the Goldfield hills.

The basalt is for the most part a dense, compact, dark-gray or black rock, in some instances with phenocrysts equal to the groundmass in bulk and in others without phenocrysts. The phenocrysts, which reach a maximum length of one-fourth inch, include glassy striated laths of feldspar, stocky black columns of augite, and rounded grains of iron-stained glassy olivine. Vesicular facies occur at the top and bottom of the two main flows that compose the 350 feet of basalt. With the introduction of vesicles much of the rock takes on a magenta-red color. The vesicles, which reach a maximum length of 2 inches, are usually elongated parallel to the flow bedding. Some of them are filled by white granular calcite and others by chalcedony. Certain bands contain in a basalt matrix many fragments of basalt, indicating that some portions of the rock solidified before cessation of movement in the magma. Surfaces of flows are often ropy.

Under the microscope the groundmass is usually seen to be holocrystalline and composed of plagioclase laths, augite columns, and magnetite grains. Rarely a little dark glass is also present, and in other thin sections large areas of augite inclose plagioclase laths in the manner of the ophitic texture. A reddish-brown serpentine is developed at the expense of olivine, and a little calcite is formed from plagioclase.

The basalt forms a typical mesa, and buttes isolated in the desert gravels have been carved from it by erosion. This rock is to be correlated with other basic flows widely distributed throughout the area surveyed, which are presumably of late Pliocene or early Pleistocene age.

STRUCTURE.

As Ransome has shown, the Goldfield hills have a domical structure, the oldest formations being confined to the central portion of the hills. He further shows[a] that the older Tertiary rocks have been subjected to considerable folding and some faulting. The Siebert lake beds usually dip away from the central portion of the Goldfield hills. Even the later basalt has been subjected to tilting, in the main away from the center of the dome, and also to some normal faulting. These faults have usually an east-west or north-south strike.

ECONOMIC GEOLOGY.

The ore deposits of Goldfield have been treated at some length in the bulletin already mentioned.[b] Outside of the special area few prospects exist. The andesite and rhyolite 3 miles southeast of Preble Mountain have been altered similarly to those of the productive territory in Goldfield, and the area has been located by prospectors.

ALKALI SPRING FLAT.

The broad valley north of Montezuma Peak is separated from Big Smoky Valley by a gravel-covered divide. The valley has gently sloping sides, except on the west, where it rises rather steeply to the Lone Mountain foothills. The lowest portion, 4,850 feet above sea level, is occupied by a playa, situated considerably west of the center of the valley. Inliers of rock do not occur at a distance from the encircling hills, and the recent alluvial deposits are probably deep. The Ramsey and Klondike wells struck water at 240 and 140 feet, respectively. The Ramsey Well is 100 feet higher than the Klondike, and water could probably be obtained near the playa at shallower depths.

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[a] Ransome, F. L., Bull. U. S. Geol. Survey No. 303, p. 21.

[b] Idem, pp. 22-39.

SOUTHERN KLONDIKE HILLS.

TOPOGRAPHY AND GEOGRAPHY.

Between Ralston Valley and the flat east of General Thomas Camp are two groups of conical hills and ridges joined by a broad sag formed of Siebert lake beds. These hills are separated from the Goldfield hills by a depression filled with Recent alluvial deposits. The highest peak in the northern part of the hills reaches an altitude of 7,000 feet. The east slope of the group is comparatively gentle, while the west slope is steep. The hills are bare of timber and without water.

GENERAL GEOLOGY.

The formations of the Southern Klondike hills, named in order from the oldest to the youngest, include Cambrian sedimentary rocks, post-Jurassic granite, earlier rhyolite, Siebert lake beds, earlier quartz latite, basalt, later rhyolite, later quartz latite, and earlier alluvium. The mapping to the south of the area of Siebert lake beds is approximately correct, while that to the north is less accurate.

SEDIMENTARY ROCKS.

Cambrian.—Cambrian rocks cover a considerable area in the southern part of these hills. They consist of an interbedded series of limestones, jasperoids, and shales, named in the order of their abundance. Neither the top nor the bottom of the series is exposed, but it is many hundreds of feet thick. The limestone, by far the predominant member of the series, is dark gray or blue black, fine grained, compact, and crystalline. Bedding planes are from 2 to 3 feet apart. Weathered surfaces are blackish gray in color and smooth in contour, although minor irregularities are produced by the varying hardness of the rock. The limestone grades into a silicified facies, best styled a jasperoid. This is ordinarily a dense-banded rock of black and gray color, the laminæ of which are in many cases but one-fourth inch in thickness. It breaks with a conchoidal fracture. The slaty shale is rather fine grained and of dark-gray or greenish-gray color. Even minor lenses and thin parting bands of of fine-grained sandstone are rather unusual. The sediments form hills of moderate slope with numerous exposures. No fossils were found, but the lithology of the series is similar to that of the Lone

Mountain hills to the west, and in consequence the rocks are almost certainly Cambrian.

Siebert lake beds.—The intensely dissected gap between the two groups of hills is composed of white or yellow, well-bedded tufaceous sandstones, conglomerates, and clays, slightly consolidated. About 400 feet of this formation is exposed. Thin sheets of rhyolite appear to be interbedded with the sediments at the south end of the exposures. These soft horizontal beds are eroded into numberless low rounded hills and gullies. Veins of white calcite from one-fourth inch to 1 foot thick cut the sediments and stand in relief on weathering. These beds are similar lithologically to the Siebert lake beds of Tonopah,[a] and like them have thin sheets of the Tonopah rhyolite near their top.

Older alluvium.—North of the large isolated latite cone on the west side of the hills occur small exposures of white sandstones and conglomerates. The pebbles and bowlders consist of latite and biotite-hornblende andesite. These beds are perhaps to be correlated with the older alluvium, probably of late Pliocene or early Pleistocene age.

IGNEOUS ROCKS.

Post-Jurassic granite.—Three small areas of granitoid rocks lie near Southern Klondike. Three-fourths of a mile northwest of the village a granite sheet 250 feet thick, which courses northeast, injects the Cambrian rocks parallel to their bedding. This is a fine-grained rock, although minor portions are of medium to coarse grain. Under the microscope it shows as a rather fresh muscovite granite in which some oligoclase occurs with orthoclase. The quartz shows gentle undulose extinction, but the deformation indicated is not great. A little sericite and less kaolinitic material has been developed in the feldspars. This granite weathers into small rounded bowlders, and exposures are scarce. It is complexly cut by joints 6 inches apart, and in those parallel to the bedding of the surrounding sediments quartz veins occur. A small area of a similar muscovite granite of medium grain is exposed one-fourth mile west of Southern Klondike. An aplitic sheet of the same rock injects the limestone in a mining tunnel at the village. The sedimentary rocks are more or less metamorphosed in the vicinity of the granite, the shale in particular being altered to a knotted silvery schist. Granite cuts the Cambrian rocks and occurs as pebbles in the Siebert lake beds. It is believed to be of post-Jurassic age.

Earlier rhyolite.—Prior to the eruption of the earlier rhyolite which occurs near Southern Klondike the Cambrian rocks and the granite were eroded into a group of hills of slightly greater relief than the present Southern Klondike hills. Since that extrusion erosion has removed considerable masses of the once more extensive rhyolite and partially exhumed the sedimentary rocks. The rhyolite at the northern boundary of the area mapped, on the west side of the hills, is also probably the earlier rhyolite. It occurs in flows and dikes, the flows overlying the Cambrian rocks, the dikes clearly cutting them. The white or pinkish or lilac-white lithoidal groundmass predominates in bulk over the small phenocrysts, among which feldspar is more abundant than quartz. Narrow wavy flow bands wrap around the phenocrysts. One-half mile north of Southern Klondike a resin-colored glassy facies was noted. Rhyolite tuffs and flow breccias are associated with the normal igneous rock near the boundary of the area.

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[a] Spurr, J. E., Prof. Paper U. S. Geol. Survey No. 42, 1905, pp. 51–55.

The rhyolite is cut by two sets of joints from 2 to 5 inches apart, and the flow parting constitutes a third plane of weakness. In consequence the residual fragments are rectangular or platy. Weathered fragments are characterized by small pits, the casts of feldspar phenocrysts. The rhyolite forms yellowish or slightly pinkish-white conical hills or low areas. The single slide examined has a brown devitrified groundmass showing flow lines and spherulites. Quartz and orthoclase predominate in the groundmass, while the rather sparse phenocrysts are orthoclase, quartz, and plagioclase. The rock is a rhyolite tending toward latite. The earlier rhyolite is tentatively correlated with the Miocene Tonopah rhyolite-dacite [a] of Tonopah, a correlation already suggested by Spurr [b] for the northern mass.

Earlier quartz latite.—In the northwest portion of the hills, near the areal boundary, is an outcrop of quartz latite of dull-lilac or medium-gray color, which, however, as mapped, may include some basalt. The dense groundmass contains numerous crystals of white striated and unstriated feldspar reaching a maximum length of one-eighth inch, and black mica. Under the microscope the predominant groundmass shows as a devitrified glass containing considerable quartz. Plagioclase and orthoclase are equally abundant phenocrysts, while biotite is in some specimens surrounded by a reaction rim of magnetite. Magnetite, apatite, and zircon are accessories. The latite flow overlies the Siebert lake beds. The rock is rather similar to the later rhyolite of the Goldfield hills, although less siliceous, and the two are perhaps contemporaneous. The Goldfield rhyolite underlies and is older than the basalt.

Basalt.—The large mass of volcanic rock capping the Siebert lake beds northeast of Southern Klondike appears to be an eroded basalt flow, as are the hills between this mass and the large playa crossed by the road from Tonopah to Cactus Spring. It is probable that this basalt is to be correlated with that of Tonopah and the Monitor Hills and that it is of Pliocene age.

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[a] Spurr, J. E., Prof. Paper U. S. Geol. Survey No. 42, 1905, pp. 51–55.
[b] Op. cit., p. 99.

Later rhyolite.—The eastern side of the hills on the boundary of the area is formed of rhyolite in flows. The groundmass, much of which is glassy, when fresh is white or light gray, but in places it is stained pink, yellow, or brown by iron oxides. Medium-sized feldspar phenocrysts are more abundant than those of quartz and biotite. This rock is perhaps contemporaneous with the Oddie rhyolite[a] of Tonopah, which is younger than the Siebert lake beds.

Later quartz latite.—The prominent isolated cone between the roads 4 miles west of north of Southern Klondike, several small exposures east of this cone, and a considerable portion of the northern part of the hills east of the Tonopah-Goldfield road are composed of a lilac-gray igneous rock. A black glassy facies occurs on the east side of the cone. As phenocrysts, fresh and altered, feldspars are more abundant than quartz grains, biotite tablets, and hornblende columns. Under the microscope the groundmass appears as a spherulitic glass in which considerable calcite is developed. Orthoclase predominates over plagioclase, which proved in one determination to be an acidic labradorite. Apatite, magnetite, and zircon occur as accessories.

The latite is characterized by vertical flow lines, particularly near the contact with the rhyolite, and the mass is probably a volcanic neck. It is very similar to the Brougher dacite[b] of Tonopah, although somewhat richer in hornblende, and the two are presumably contemporaneous and of Pliocene age.

STRUCTURE.

The Cambrian rocks have been complexly folded, the chief structural feature being an anticline with a northeast-southwest axis. Superimposed upon this anticline are numerous lesser anticlines and synclines, and at many points the beds are intensely crenulated. The rocks are horizontal or dip at varying angles up to 90°, those of 45° predominating. The folding probably immediately preceded and accompanied the granite intrusion. Faults of small displacement occur, and brecciation is common. The sediments are cut in every direction by veins of calcite and less commonly by those of quartz. The veins are not folded, and hence fracturing occurred after the folding of the series and was probably connected with the granitic intrusions. Faulting and some tilting have occurred since the formation of the Tertiary rocks, although it is not known whether the tilting is dependent on faulting or is due to flexing without rupture. On the southern edge of the hills dikes of earlier rhyolite are faulted, but lack of time did not permit their being mapped. Some faulting also occurred after the formation of the ore deposits in the northern part of the hills. The basalt northeast of Southern Klondike dips to the south.

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[a] Spurr, J. E., Prof. Paper U. S. Geol. Survey No. 42, 1905, pp. 49–50.

[b] Ibid., pp. 44–48.

ECONOMIC GEOLOGY.

GOLD AND SILVER.

Gold and silver ores were discovered in the Cambrian rocks at Southern Klondike in March, 1899, by J. G. Court and T. J. Bell. Since that time the prospects have been worked more or less continuously. It was while on a trip to these prospects in 1900 that J. L. Butler discovered the veins at Tonopah. From one group of claims shipments of ore ranging in value from $200 to $284 per ton and aggregating $50,000 are reported. Several thousand feet of tunnels, shafts, and inclines have been driven. In June, 1905, eight men were at work in the camp.

The ore deposits are of three kinds—first, quartz veins[a] which are parallel to the bedding of the Cambrian rocks, and which carry predominant silver values; second, veins along the contact of the sedimentary rocks and rhyolite dikes, the values, about $45 per ton, being predominantly gold, and third, thin veins of quartz carrying silver-bearing galena and cerussite in granite along joint fractures parallel to the bedding of the surrounding Cambrian rocks. The veins along contacts apparently show post-mineral faulting.

The quartz veins parallel to the bedding planes, which occur at and 1 mile east of the village of Southern Klondike, are of greatest value and interest. These are tabular lenses of quartz, from a few inches to a foot or more in thickness. Horses of limestone are included. Adjacent veins connected by cross veins of quartz or completely separated by thin bands of limestone form in some instances mineralized zones 14 feet thick. Quartz appears to have filled a fissure in the limestone, brecciation of the limestone having accompanied the fissuring. The contact between the limestone and quartz is sharp, and important silicification of the limestone has not occurred. Vugs lined with acicular quartz crystals are rather characteristic.

The original sulphides deposited simultaneously with the quartz and disseminated in small masses in it are, in the order of their abundance, galena, copper sulphide,[b] and iron pyrites. The secondary ores include cerargyrite, chrysocolla with less malachite and azurite, specular hematite, and cerussite in brownish granular masses and to a less extent in crystals. These secondary minerals surround the sulphides and fill cavities and cracks in the quartz. Some calcite and gypsum, accompanied by sulphur, are secondary gangue minerals. Sulphur in places forms masses 3 inches in diameter. Assays did not detect the presence of gold at the surface, although gold values are encountered 50 feet below the surface in one tunnel. One small aplite dike was noted near a quartz vein, and masses of quartz rhyolite are not far distant, although their proximity has not apparently determined an unusual abundance of quartz veins. The prospects are yet well above water level.

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[a] For a detailed description of this type see Spurr, J. E., Economic Geology, vol. 1, 1906, pp. 369-382.

[b] Stetefeldtite, according to J. E. Spurr, Trans. Am. Inst. Min. Eng., 1905, p. 961.

In Southern Klondike fissures and brecciated zones were opened in the Cambrian sediments along bedding planes. Water filled these cavities with silica and lead, copper, and iron sulphides carrying silver and less gold. The quartz veins have since been fractured and faulted, and surface waters have developed a number of secondary minerals. In this district the presence of quartz veins at the contact of rhyolite and limestone shows the gold veins to be of late Tertiary age, but the more important silver veins are presumably of post-Jurassic and pre-Tertiary age.

Water is obtained at the Klondike Well, 4 miles distant. The Southern Klondike hills are bare of timber. When the district was visited Tonopah was the supply and shipping point.

The earlier rhyolite northwest of the Tonopah-Goldfield road near the boundary of the area mapped has locally been silicified and kaolinized by mineralizing waters, and in it some quartz veins occur. The reported values are in gold with less silver. The Kankakee Mining Company has a 100-foot shaft, which passes through rhyolite, tuffs, and breccia. Dense quartz fills the interstices of breccia and also occurs in veins. The ore is free milling and is said to run about $30 in gold and silver per ton, although assay returns have reached $317. Spurr[a] says, concerning these veins: "Through these rhyolites run strong and persistent veins of quartz and delicately colored chalcedony veins, sometimes containing pyrite. In some parts of some of these veins, especially in the oxidized portions, rich assays have been obtained." In his report on Tonopah Spurr correlates these veins with those of the Tonopah rhyolite-dacite.[b]

IRON ORES.

A several places northwest of Southern Klondike lenses of porous hematite occur in limestone. These masses occupy joints in the limestone and are from 5 to 10 feet wide and from 50 to 100 feet long. The hematite appears to be partially a replacement of limestone and partially a cavity filling. Cubes of pyrite are present in the neighboring limestone. These masses of iron ore are probably gossan and with depth will pass into pyrite veins.

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[a] Spurr, J. E., Bull. U. S. Geol. Survey No. 213, 1903, p. 87.

[b] Spurr, J. E., Prof. Paper U. S. Geol. Survey No. 42, 1905, p. 99.

RALSTON VALLEY.

The south end of Ralston Valley is within the area surveyed and lies between the Monitor, Goldfield, and Southern Klondike hills and the Cactus Range. Hills surrounded by gravels extend from the Cactus Range northeastward toward the Kawich Range and separate Ralston Valley from Cactus Flat, and on the divide the Recent gravel deposits are probably but a few hundred feet thick. Ralston Valley is very shallow, the rim of hills being in many places but 200 feet above the playa (elevation, 5,270 feet). Low sand dunes lie on the northeast of the playa. A well sunk in the playa struck water at a depth of 240 feet.

STONEWALL FLAT.

Stonewall Flat, of northeast-southwest trend, is inclosed by the Cactus Range, Stonewall Mountain, the Goldfield hills, and the Mount Jackson hills. A gently sloping detrital divide with rock inliers separates it from Ralston Valley to the north, while the detrital barrier between it and the valley north of Slate Ridge is less than 100 feet high. Several small playas, between 4,700 and 4,800 feet above sea level, occupy minor depressions in the valley. The playas nearest the Cactus Range are encircled by low sand dunes. A well on the Goldfield-Gold Crater road, 2 miles east of the largest playa, struck water at a depth of about 110 feet. The water contains small amounts of salt and probably sodium carbonate. On the west side of the largest playa are low dissected bosses of dazzling white older alluvium, the highest of which are 25 feet above the present playa. Massive beds of white or cream-colored clay of fine texture, with thin interbedded layers of white limestone, are exposed. A number of compact lenticular lime-carbonate concretions, with hackly surface, which reach a maximum length of 6 inches, are embedded in the clay. These beds resemble those of Gold Flat and the valley north of Slate Ridge and have suffered about the same amount of erosion. They were evidently deposited in an ancient playa, possibly of late Pliocene, but probably of early Pleistocene, age.

STONEWALL MOUNTAIN.

TOPOGRAPHY AND GEOGRAPHY.

Stonewall Mountain rises from the northwest border of Pahute Mesa. It was named, according to some, from Gen. Stonewall Jackson, but by others the name is said to have been derived from the precipitous, wall-like northern face of the mountain. The rugged mountain group, 9 miles in diameter, is formed of sharp peaks and steep ridges culminating in a summit 8,390 feet high. Stonewall Mountain is an excellent example of the symmetrical erosion of a homogeneous mass of an approximately circular horizontal plan. Deep canyons radiate from the central peak, ending at the alluvial slopes 2,500 to 3,000 feet below. The most striking feature of the mountain is the fault scarp at Stonewall Spring, a sheer wall 800 to 1,000 feet high. Erosion has cut partially through this scarp, forming a narrow V-shaped gap, the lowest point of which is at least 100 feet above the stream bed to the south. Behind this wall the valley is broad and U-shaped, regaining its V shape some distance back in the mountains. Other streams near by are characterized by narrow canyons, which open upstream into more mature valleys.

The mountains above an elevation of 6,100 feet are clothed with a sparse although locally heavy growth of juniper, piñon, and mountain mahogany. Excellent pasturage covers the higher peaks and valleys. Groves of the tree yucca occur on alluvial slopes to the west and on Pahute Mesa to the southeast. Stonewall Spring yields daily about 3,000 gallons of pure cold water. A stream 100 yards long flows from a spring in the gulch one-half mile east of Stonewall Spring. Another spring is located 1 mile west of the culminating peak of the range.

GENERAL GEOLOGY.

The formations of Stonewall Mountain are, in ascending order, Cambrian limestone, post-Jurassic granitoid igneous rocks, earlier rhyolite, quartz syenite and quartz-monzonite porphyry, Siebert lake beds, later rhyolite, and basalt.

SEDIMENTARY ROCKS.

Cambrian.—Three small masses of dark-gray crystalline limestone, cut by many white calcite veinlets, protrude from the igneous rocks near the north edge of the mountain. Angular inclusions of limestone and jaspilite are embedded in the older rhyolite, the monzonite porphyry, and the basalt. The limestone is similar lithologically to that of the Cuprite mining district, and, like it, is probably of Cambrian age. In contact with quartz-monzonite porphyry, near the northwest boundary of the mountain mass it has been metamorphosed to a white marble containing epidote.

Siebert lake beds.—Incoherent, well-bedded tuffaceous sandstones and conglomerates of red, yellow, white, and greenish-white color cover a small area east of Stonewall Spring. The bowlders, which are well rounded to semiangular, are largely of the earlier rhyolite. A thickness of about 500 feet is exposed. These beds are without much doubt the equivalent of the Siebert lake beds.

IGNEOUS ROCKS.

Post-Jurassic granite and granite porphyry.—A few inclusions of granite occur in the earlier rhyolite and prior to the extrusion of that rock granite may have been exposed in these mountains. A narrow dike of granite porphyry cuts the easternmost limestone. This rock has a finely granular yellowish groundmass in which are inclosed medium-sized quartz and feldspar phenocrysts. In the field this resembles the granite porphyry near Alkali Spring in the Silver Peak Range and it may be genetically related to the post-Jurassic granites. Angular fragments of a gray monzonite porphyry occur in the earlier rhyolite near the summit of the group and these may be correlated with similar rocks of the Silver Peak Range that are also related in origin to the post-Jurassic granites.

Earlier rhyolite.—The most widely distributed formation of Stonewall Mountain is a rhyolite characterized by many small colorless and glassy or white and opaque unstriated feldspar phenocrysts. Near Stonewall Spring the rhyolite is medium gray and compact; that of the highest peak is also compact and of a faded red color; the rhyolite of the small hill in the detrital apron on the southwest side of the mountain is a gray lithoidal rock. The rhyolite from the last two localities contains biotite phenocrysts.

An indistinct original banding is locally present and some facies are a flow breccia. The rhyolite is probably a flow, although the vertical position of the banding in places and the texture of some facies indicate that the rock may possibly be an intrusive mass. The rhyolite as exposed at present is several thousand feet thick, and the granitoid habit of the quartz syenite which injects it suggests that it was probably once much thicker. The rhyolite has well-developed joints over large areas which express themselves in the topography as straight elements. Where the joints are less closely spaced the rhyolite weathers in rounded forms like a granite.

Microscopic examination shows the rhyolite to have either a devitrified glassy or a microgranitic groundmass composed of predominant orthoclase with fewer quartz grains and many small magnetite cubes. The groundmass varies widely in grain from one part of the thin section to another, but is everywhere rather fine grained. Orthoclase phenocrysts, many of them microperthitic, with ragged borders which inclose some of the groundmass anhedra, are abundant. Rarely plagioclase laths, well-formed biotites, very ragged hornblende, and in some thin sections one or more quartz phenocrysts are associated. Zircon and apatite are accessories.

The mature topography of Stonewall Mountain shows that the rhyolite is old, and pebbles of it occur in the Siebert lake beds. It is believed to be older than the rhyolite of the Kawich Range, with which it has no lithologic affinities, and is probably of early Eocene or even late Cretaceous age.

Quartz syenite and quartz-monzonite porphyry.—Dikes and elongated masses of quartz syenite and quartz-monzonite porphyry, which grade into one another and are hence contemporaneous, intrude the earlier rhyolite at widely separated localities in the mountain. Dikes of quartz syenite less than 200 feet wide intrude the earlier rhyolite on the fault scarp just east of Stonewall Spring. The quartz syenite is a grayish-white, medium-grained granitoid rock composed of unstriated feldspar with a little biotite. Microscopic examination shows the presence of a few small wedges of quartz between the feldspar grains and the biotite tablets. Ilmenite, apatite, and zircon are accessories. The granitoid habit of these small masses indicates that its magma solidified beneath a considerable depth of rhyolite now removed by erosion.

The quartz-monzonite porphyry is typically porphyritic in habit, with a gray and black speckled holocrystalline groundmass. The phenocrysts, which predominate over the groundmass, include white or gray glassy feldspar, striated or unstriated, and black or bronze-brown biotite. The largest phenocrysts are one-fourth inch in length. The contact facies of the dike three-fourths of a mile southeast of the summit of Stonewall Mountain is of slightly finer grain and includes many fragments of the earlier rhyolite. The rock weathers into rounded bosses and disintegrates into spheroidal bowlders stained brown or reddish by iron oxides. The microscope shows that the microgranitic groundmass is composed of orthoclase grains, many of them twinned according to the Carlsbad law, with a few associated quartz wedges and biotite shreds. The phenocrysts include both plagioclase, in large complex individuals, and orthoclase. Phenocrysts of biotite and smaller ones of light-green augite are also present. Magnetite, apatite, and zircon are the accessory minerals. Calcite, sericite, and kaolin are present as alteration products of the feldspars.

One and three-fourths miles upstream from the easternmost area of Cambrian limestone a poorly exposed black glass with rather numerous feldspar phenocrysts apparently cuts the earlier rhyolite. The exposure is too small to map. Under the microscope this proves to be a glass with orthoclase and a few bluish-green augite phenocrysts. It may well be a glassy form of the quartz syenite. A small fragment of hornblende andesite, unlike any rock exposed in the mountain, is included in the thin section.

The quartz syenite and quartz-monzonite porphyry of Stonewall Mountain intrude the earlier rhyolite, and pebbles are embedded in the Siebert lake beds. They most closely resemble the post-Jurassic monzonite porphyry of the Silver Peak Range (see p. 59), although they are not very different from the monzonite porphyry of the Kawich Range and their correlation with the latter is more nearly correct. The rocks are believed to be of late Eocene age.

Later rhyolite.—The later rhyolite forms the low, massive brown and gray domes of the eastern part of Stonewall Mountain. Two outlying hills on Pahute Mesa to the south are of the same formation. The later rhyolite has a dense gray stony to glassy groundmass. In it are numerous medium-sized glassy unstriated feldspar and fewer rounded quartz phenocrysts. The feldspar crystals often exhibit beautiful plays of color, purples and blues being refracted from numerous cracks. The glassy facies locally show well-developed flow lines and spherulites, while slightly vesicular facies also occur. The later rhyolite breaks into platy fragments and in places a granite-like weathering is developed. The rhyolite flow, as now exposed, 1,200 feet thick, is in broad, gentle flexures which may be due in part to the slightly uneven surface upon which it flowed. Microscopic examination shows a turbid glass in which orthoclase and quartz and fewer acidic plagioclase phenocrysts are associated. A little magnetite is also present.

For a distance of 2 miles west of the rhyolite, pebbles of black glassy obsidian are common upon the surface of Stonewall Mountain. These pebbles may indicate that the rhyolite once extended some distance farther west, although similar rocks were not noted in the later rhyolite section.

The later rhyolite overlies and is in consequence younger than the Siebert lake beds. The contact between the rhyolite and the basalt which forms the top of Pahute Mesa at the northeast corner of Stonewall Mountain was examined at one point. The contact is slightly undulating, and the base of the overlying rhyolite for 5 to 6 feet is a flow breccia of massive blocks of vesicular rhyolite. This apparently indicates that the rhyolite is younger than the basalt beneath it. The topography of the rhyolite, however, is so much more mature than that of the Pahute Mesa basalt that it is believed that the rock here underlying the rhyolite is a portion of an older basalt which extended from Stonewall Mountain as a shelf and which happened to be on a level with Pahute Mesa. The later rhyolite is probably to be approximately correlated with the later rhyolite of the Southern Klondike hills.

Basalt.—A small mass of a grayish-black basalt outcrops 1 mile east of south of Stonewall Spring. Basalt breccias indicate that it is a flow. The age of this rock is unknown, but from the apparent absence of its bowlders in the Siebert lake beds it is probably to be correlated with the later basalt of the Goldfield hills.

STRUCTURE.

The Cambrian limestone is practically horizontal, the folding being broad and open like that of the hills of the Cuprite mining district. In restricted areas, however, the rock is closely folded. Prior to the extrusion of the earlier rhyolite the Paleozoic rocks appear to have had a gently accentuated topography. The most striking structural and topographic feature of Stonewall Mountain is the fault on the front of the mountain group, near Stonewall Spring. This fault strikes N. 65° E. and dips 70° N. Minor faults and sheeting parallel to the main fault occur for a distance of one-half mile south of the mountain front. The Siebert lake beds strike east and west and dip 5° to 50° N. This fact probably indicates that Stonewall Mountain is on the upthrown side of the fault. The fault fissure was healed by a quartz vein and has been reopened several times and again healed. (See p. 88.) Since the fissure filling erosion has uncovered the fault and a secondary fault scarp, whose position is determined by the resistant quartz vein, has been formed. The topographic form of the valley of the Stonewall Spring drainage line (see p. 84) indicates that in comparatively recent time the mountains behind the fault line have been uplifted. Fig. 7 is a section through the north side of Stonewall Mountain.

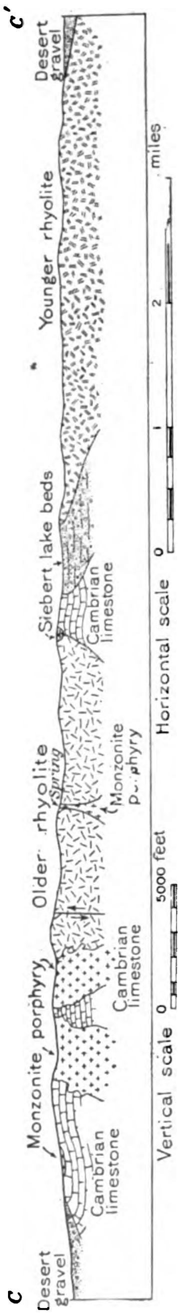

FIG. 7.—Section across north face of Stonewall Mountain, through Stonewall Spring.

ECONOMIC GEOLOGY.

Quartz veins and stringers filling faults, joints, and the cavities of brecciation are very abundant in the earlier rhyolite, quartz-monzonite porphyry, and quartz syenite near Stonewall Spring. The most prominent vein follows the fault scarp immediately south of the spring. The quartz vein is in some places simple and 40 feet wide; in others it is complex and composed of many parallel veins. This vein or other veins of approximately similar strike extend 2 miles west and 1 mile east of the spring. The quartz is white or colorless, rarely greenish yellow, and is beautifully crustified. Vugs with quartz crystals or mammillary quartz are common. Movement reoccurred along this fault and the quartz has locally been fractured and slightly displaced, later quartz filling the cavities. Heavy stains of limonite and slight stains of azurite were noted in the quartz, and pyrite is locally developed. Prospectors report from a trace to $6 in gold per ton at a number of places on this vein. Similar but smaller quartz veins occur throughout the areas of earlier rhyolite and quartz-monzonite porphyry.

A prospect is located in the Cambrian limestone area 2 miles east of Stonewall Spring. A thin vein of quartz cuts a granite-porphyry dike, which here intrudes limestone. The quartz is slightly limonite stained and said to carry from $2 to $56 in gold per ton.

RANGES NORTH OF PAHUTE MESA.

To the north of Pahute Mesa, which occupies the central portion of the area surveyed, lie the Cactus, Kawich, Reveille, and Belted ranges. These, with the exception of the Cactus Range, trend north and south. They have as their predominant formation a rhyolite of early Miocene age.

CACTUS RANGE.

TOPOGRAPHY AND GEOGRAPHY.

The Cactus Range lies between Stonewall and Cactus flats. To the north its outlying hills are separated from the Monitor Hills by Ralston Valley; its low southern portion is buried beneath lava flows of Pahute Mesa. The range as defined is 22 miles long and has a crest line coursing northwest. The low central part is almost cut in two by gently sloping valleys filled with alluvial material. To the north of this median line the range culminates in Cactus Peak, a symmetrical cone 7,550 feet high and a landmark visible for many miles. The highest peak of the range south of the center line is a black massive mountain 7,600 feet high.

Piñon and juniper grow sparsely on the higher parts of the range south of the median line, and the tree yucca abounds on the lower hills and upper alluvial slopes. Good grazing is found on the alluvial slopes next to the mountains and in some of the valleys. Cactus Spring has a daily flow of about 500 gallons of clear cold water. The water of Alkali Spring is cool, but slightly saline. Several other small water holes are reported to the west and north of Alkali Spring. Antelope Spring flows from 300 to 400 gallons of cool palatable water daily, and two smaller evanescent springs are situated in gulches to the south within one-half mile of Antelope Spring.

GENERAL GEOLOGY.

The succession of formations exposed in this range, from the base up, is as follows: Pogonip limestone, Eureka quartzite, Weber conglomerate, granite, diorite porphyry, hornblende-biotite latite, earlier rhyolite, biotite andesite, augite andesite, later tuffs (?), later rhyolite (?), and basalt.

SEDIMENTARY ROCKS.

Pogonip limestone.—A small exposure of dark-gray fine-grained limestone, surrounded by alluvial deposits, occurs in the broad valley 3 miles south of the Goldfield-Cactus Spring road. This limestone is cut by numerous small white calcite veins. On lithologic grounds it is probably the Pogonip limestone of Ordovician age. Bowlders of similar limestone are embedded in rhyolitic tuffs near by and fragments of limestone and jasperoid are inclosed in the rhyolite at several places and in a granite porphyry in the northern part of the range. These fragments were probably derived from Ordovician or Cambrian limestones.

Eureka quartzite.—Two miles southwest of Antelope Spring an area of quartzite lies unconformably below the surrounding rhyolite. This is a fine- to medium-grained quartzite of white, yellow, or red color and is cut by small stringers of white quartz. From its lithologic character it is considered to be the Eureka quartzite (Ordovician).

Weber conglomerate.—Three miles west of south of Cactus Spring a mass of rusty-looking sedimentary rocks, one-half mile in diameter, protrudes through rhyolite. About 150 feet of conglomeratic beds, with the matrix of sand and small pebbles thoroughly cemented, are exposed. Embedded in this matrix are many beautifully rounded pebbles of green and black flint and jasperoid, white quartzite, and black limestone. The roundness of the pebbles, the largest of which are 4 inches in diameter, indicates a long period of attrition and the conglomerate is probably of marine origin. Prior to their inclusion in the conglomerates the pebbles, probably derived from Cambrian, Ordovician, and Silurian rocks, were cut by quartz and calcite veinlets and the limestone silicified to jasperoid. The conglomerate is thus much younger than the Pogonip limestone, but since it contains no granite or diorite pebbles it is believed that it is of Carboniferous age and that it is to be correlated with the Weber conglomerate of the Belted Range.

IGNEOUS ROCKS.

Post-Jurassic granite porphyry and granite.—Midway between Cactus Peak and Cactus Spring is a small area of granite porphyry that is poorly exposed, but lithologically distinct from the surrounding rhyolite. The pinkish-gray rock is of well-developed porphyritic habit, with a finely crystalline groundmass. The phenocrysts, which exceed the groundmass in bulk, are pink glassy feldspar tablets up to three-fourths of an inch in length, a few smaller quartz grains, and fairly abundant biotite flakes. In it are fragments of Paleozoic sedimentary rocks. Under the microscope the groundmass is seen to be a micrograhitic mosaic of orthoclase and quartz with here and there a little plagioclase and biotite. The orthoclase phenocrysts, many of which have zonal structure, are in places twinned according to the Carlsbad law. Quartz, biotite, and a few plagioclase phenocrysts are associated. Magnetite and zircon occur as accessory minerals. Both quartz and orthoclase phenocrysts show undulose extinction, which in certain instances is rather strongly developed. The plagioclase phenocrysts and the feldspars of the groundmass are turbid through kaolinization. This granite porphyry closely resembles some of those of post-Jurassic age. Inclusions of a siliceous granite occur in rhyolite at a number of places.

Pre-Tertiary diorite porphyry.—Two miles north of Antelope Spring is a small area of greenish-gray diorite porphyry. The rock has a well-developed porphyritic texture; small gray striated feldspars, grayish-green altered hornblendes, and much smaller black micas lie in a fine-grained gray groundmass. Under the microscope the groundmass appears as a fine microgranitic mosaic of plagioclase and some orthoclase. Of the phenocrysts already mentioned both plagioclase and hornblende are much altered, the plagioclase being sprinkled with epidote, calcite, and zoisite, and the hornblende being more or less completely replaced by epidote, chlorite (ripidolite, in part), and calcite. Ilmenite and apatite are accessory minerals. This rock is practically identical with the older pre-Tertiary diorite porphyry of the Lone Mountain foothills.

Hornblende-biotite latite.—On the west side of the Cactus Range, north of Wellington and south of the median line of the range, low rounded bosses of a much altered greenish-gray rock protrude from beneath the younger rhyolite. The dull groundmass contains biotite plates, white or pale-green areas, apparently altered feldspar, and dark-green areas, probably altered hornblende, while the weathered surfaces show numerous casts of these phenocrysts. The rock contains many well-rounded pebbles, some of grayish-white quartzite (Eureka?), others of the diorite porphyry last described. The largest pebbles are 3 inches in diameter. The latite appears to have flowed out upon an old erosional surface covered by well-rounded pebbles. Under the microscope the groundmass shows as a glass, now, however, much altered and composed of epidote, calcite, quartz, and orthoclase. The plagioclase phenocrysts are almost completely altered to epidote and calcite, with less chlorite, quartz, and zoisite. The hornblende phenocrysts are altered to the same minerals, although zoisite is as a rule absent. Biotite is replaced by chlorite in association with sagenitic webs of rutile. The phenocrysts and groundmass have thus been altered similarly, although the secondary minerals of the phenocrysts are coarser in grain than those of the groundmass.

Wherever the contact with the rhyolite was seen the latite appears to be the older, a view supported by the absence of rhyolite pebbles in it and by the intense alteration and deformation which it has suffered. Petrographically the latite is rather similar to the later andesite of Tonopah,[a] but mineralogically it is more closely allied to the monzonite porphyry of the Kawich Range; it is therefore tentatively considered the effusive equivalent of that formation and is thus probably of Eocene age.

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[a] Spurr, J. E., Prof. Paper U. S. Geol. Survey No. 42, 1905, p. 33.

Earlier rhyolite.—The most widespread formation of the Cactus Range is a rhyolite which occurs in flows. Throughout the range it appears to bear similar relations to the other Tertiary rocks and in the main probably represents a single period of rhyolitic volcanism. More detailed work may, however, prove that some of the rhyolites near Cactus Peak are younger than those of the central and southern portions of the range.

The rhyolites vary among themselves in color, in character of groundmass, and in the relative abundance of the various phenocrysts. The predominant type is a white or gray rock of lithoidal or glassy groundmass, in which are embedded abundant medium-sized, slightly smoky quartz and glassy orthoclase phenocrysts; biotite phenocrysts are small and inconspicuous or absent. Other phases of the rhyolite are black, purple, or red in color. The phenocrysts of quartz are typically corroded grains, although some exhibit the dihexagonal pyramid and prism. Wavy flow bands of slightly different color traverse the groundmass. In many beds irregular fragments of rhyolite are inclosed in a matrix of similar rhyolite, showing that portions of the magma were solidified prior to cessation of movement in the flow. The presence of well-rounded pebbles of Paleozoic rocks in the basal portions of the rhyolite indicates that the surface upon which the lava flowed was covered by such pebbles.

Microscopic examination of several thin sections shows these rocks to be normal rhyolites. The groundmass is a brown glass, and many of the phenocrysts are fractured by flow. One or two acidic plagioclase phenocrysts are present in some sections. Biotite in some instances is altered to chlorite and epidote or muscovite. Accessories are rare, although apatite and ilmenite occur.

On weathering the feldspar phenocrysts are removed and the quartz protrudes slightly. In some portions of the range the rock has the smooth contours of weathered granite, but in the vicinity of Cactus Peak the greater resistance to erosion of certain bands gives a bedded aspect to the series.

Vertical columnar parting is well developed through cooling on Cactus Peak, while on the Goldfield-Cactus Spring road horizontal hexagonal joints occur. The rhyolite is so similar to that of the Kawich, Reveille, and Belted ranges that it is considered to be also of early Miocene age.

Four areas of slightly consolidated rhyolitic sandstones and conglomerates occur in the Cactus Range. Two are on the northwest border of the range near the Cactus Spring-Tonopah road, a third is situated 2 miles southwest of Cactus Spring, and in a fourth area these rocks underlie the augite andesite on the east side of the range. The tuffaceous sandstone, which is well bedded and white or greenish in color, is but slightly consolidated and breaks down readily into a deep sandy soil. Interbedded with the sandstones are conglomerates which, in the area southwest of Cactus Spring, contain bowlders of Paleozoic limestone 3 or 4 feet in diameter. These beds are tentatively considered rhyolitic tuffs deposited in local basins during the rhyolitic extrusion. It is recognized, however, that these sediments may in reality be the Siebert lake beds, in which case the earlier rhyolite of Cactus Range is of late Miocene age and is to be correlated with the later rhyolite of the Belted Range.

Biotite andesite.—Dikes and flows of biotite andesite are widely distributed in the southern part of the Cactus Range, but do not appear to extend far north of the Goldfield-Cactus Spring road. In dikes and irregular intrusive masses and possibly in flows this rock covers considerable areas southeast of Cactus Spring, apparent dikes cut the rhyolite at Wellington, and an andesite flow caps the highest mountain in the southern half of the range. Other areas of biotite andesite occur northeast of Antelope Springs, and a traverse from Wellington to Antelope Springs crossed numerous areas of this rock too small to show on the present map. Dikes of biotite andesite occur on both sides of the Goldfield-Cactus Spring road, but these also are too small to indicate on the map.

The biotite andesite is everywhere more or less altered. The freshest rocks have a dark-gray groundmass in which are embedded abundant medium-sized phenocrysts. Striated feldspars of white color and in many cases of zonal growth are more conspicuous than the altered grayish-green biotite and hornblendelike mineral. More altered facies are greenish gray or purplish red in color. The andesite breaks into sharp joint blocks which on further alteration develop spheroidal weathering. Under the microscope this rock appears to have had originally a pilotaxitic groundmass. Plagioclase phenocrysts are common and grade in size into the laths of the groundmass. One or more orthoclase phenocrysts are present in the majority of slides. Biotite is now a pseudomorph of chlorite, calcite, epidote, quartz, and sagenitic rutile. Aggregates of chlorite, epidote, calcite, and quartz surrounded by reaction rims of magnetite appear in some cases to have the form of a pyroxene and in others that of an amphibole. Probably both minerals were originally present. These pseudomorphs, like the plagioclase phenocrysts, grade into groundmass microlites of similar form. Magnetite is a common accessory.

The biotite andesite cuts the rhyolite in dikes and caps it in flows; inclusions of rhyolite occur in the andesite, and near some of the rhyolite masses the phenocrysts of the andesite become smaller. The andesite, then, is younger than the rhyolite, and from its altered condition it is believed to be older than the augite andesite and basalt. It closely resembles the andesite of the Goldfield hills and may be contemporaneous with it. If so, it is probably of early or middle Miocene age.

Augite andesite.—A flow of dark-gray andesitic rock overlies the tuffaceous facies of the earlier rhyolite 2 miles north of Antelope Springs. In the dense groundmass are blackish-green pyroxene and amphibole columns which reach a maximum length of one-eighth inch. The rock breaks into sharply jointed blocks, in the interstices of which some epidote has developed. Microscopic examination shows that this is an augite andesite with glassy groundmass in which are numerous plagioclase laths, pyroxene crystals, and magnetite grains. Augite phenocrysts with slight zonal structure and twins parallel to the orthopinacoid are abundant. The augite is remarkably fresh, although a little secondary epidote and chlorite is locally present. A few brown hornblende phenocrysts, some of them outlined by a reaction rim of magnetite, also occur. Apatite and magnetite are present as accessory minerals.

The augite andesite forms a flow which is apparently younger than the rhyolite and, to judge from its fresh condition, is probably also younger than the biotite andesite. In the Great Basin the pyroxene andesites are of late Pliocene-Pleistocene age,[a] and their formation usually immediately preceded that of the later basalts.

Later rhyolite (?).—One mile northeast of Cactus Peak are some low hills of purplish-gray rock with rather large feldspar crystals. Tuffaceous beds underlie the igneous rock, and the two rocks are probably to be correlated with the younger tuff and the youngest rhyolite of the Goldfield hills. It is by no means impossible that the same series underlies the basalt in the west slope of the range.

Basalt.—The hill 3 miles southeast of Antelope Springs is composed of rhyolite apparently overlain by basalt, and several hills along the edge of the range on the Cactus Spring-Silverbow road are composed of a similar rock. The dissected mesa slopes on the west side of the range north of Wellington appear from a distance to be a northward extension of the basaltic rocks of Pahute Mesa. Probably to be correlated with the basalt is a reddish-brown vesicular rock which caps a low dome 1½ miles north of Cactus Peak. These basalts appear to overlie the rhyolite and they are probably of late Pliocene or early Pleistocene age.

STRUCTURE.

The Cactus Range is predominantly formed of Tertiary rocks unconformably overlying Paleozoic sedimentary rocks and granites and diorite porphyries probably of post-Jurassic age. The small areas of

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[a] Spurr, J. E., Trans. Am. Inst. Min. Eng., vol. 33, 1903, p. 333.

Paleozoic sedimentary rocks are gently folded in a manner comparable probably with the folding of the Stonewall Mountain Paleozoic rocks. Minor normal faults were observed in all the Tertiary lavas, although they are much more abundant in the rhyolite and other older formations than in the younger. The rhyolite in places is tilted at an angle of 30°, but it was not determined whether the tilting is due to faulting or to actual folding.

ECONOMIC GEOLOGY.

Wellington, formerly called O'Briens Camp, is situated on low rounded hills in the southwestern portion of the range, 11 miles south of Cactus Spring. Claims were first located in August, 1904, and when visited (July, 1905) several men were doing development work.

The country rock, the earlier rhyolite, is considerably kaolinized and silicified in the vicinity of the veins and is heavily stained by limonite. The rhyolite is apparently cut by dikes of altered biotite andesite of purple color. Both rocks along a zone striking N. 70° E. are cut by quartz veins, many of which strike parallel to the extension of the zone and dip northward. The larger veins are from 2 to 4 feet in width. Connecting these are numerous quartz stringers, which course in all directions, in many places cementing crushed portions of the rock. The quartz is semitransparent, crystalline, and for the most part white, although locally intensely stained by limonite and manganese dioxide. Vugs with small quartz crystals are very common, as is also crustification. Minor veins of calcite were observed. Differential movement has occurred parallel to some of the veins, and much of the quartz is intensely brecciated, while minor faulting across the strike was noted in several places. Microscopic examination shows that the brecciated fragments were first rimmed by fringes of quartz, the interstices being later filled by calcite and limonite. The values reported are largely gold, silver constituting but one-twentieth of the assay value. The ore is free-milling and the gold is in close association with limonite. The quartz and the contained ores were deposited in joints in the interstices of breccia and along small and possibly large fault fissures. The veins have been faulted and the quartz crushed. Only ores oxidized by surface waters have as yet been encountered.

The Cactus Mining Company has a shaft in silicified rhyolite three-fourths of a mile south of Cactus Spring. Coarsely crystalline white quartz veins, with many vugs, cut the rhyolite, and these on surface outcrops are heavily stained by iron compounds. Pyrite and chalcopyrite are sparingly present in the quartz and to a less degree impregnate the surrounding rhyolite. Free gold is reported. Both fissure filling and replacement of the country rock have occurred. To the north of Alkali Spring some quartz veins cut iron-stained kaolinized and silicified rhyolite. Prospectors report that the quartz carries low-grade values.

Over a considerable area south of the Goldfield-Cactus Spring road, beneath the north end of the andesite flow, which caps the high mountain south of the median line, and in several smaller areas the rhyolite has been silicified and kaolinized. (See fig. 4, p. 43.) Quartz veinlets occur in some of these areas. Masses of hematite and limonite outcropping 2 miles S. 60° E. of Cactus Spring may be the gossan of a pyrite vein. Malachite stains occur on joint surfaces in the biotite andesite one-half mile southeast of Cactus Spring.

HILLS BETWEEN THE CACTUS AND KAWICH RANGES.

TOPOGRAPHY AND GEOGRAPHY.

Lying between the Cactus and Kawich ranges is a rather broad ridge of north-south trend, from which low domes arise. The southern part of the ridge is a mesa sloping gently southward, evidently once a portion of Pahute mesa, but now separated from it as a result of erosion. The hills are bare of timber. A small seep, dry in summer, is located in the northern part of the ridge.

GENERAL GEOLOGY.

The formations of these hills, from the oldest to the youngest, are the following: Eureka quartzite, rhyolite, biotite andesite, and basalt.

SEDIMENTARY ROCKS.

Eureka (?) quartzite.—Mr. T. C. Spaulding states that a small hill on the north of the range is composed of lilac-gray quartzite. The quartzite is rather coarse grained and contains some tiny pebbles of kaolinized feldspar and red jasperoid. The similarity of this rock to that of Quartzite Mountain in the Kawich Range indicates that it is probably the Eureka quartzite.

IGNEOUS ROCKS.

Rhyolite.—The rhyolites are similar to those of the Cactus Range and are presumably contemporaneous. Slightly vesicular facies are, however, present.

Biotite andesite.—Masses of dark-gray biotite andesite identical with that of the Cactus Range intrude the rhyolite in the northwestern portion of the hills.

Basalt.—The greater portion of these hills is composed of black basalt with dense groundmass. The phenocrysts are striated feldspar, black pyroxene, and pellucid olivine, the feldspar and pyroxene showing a rude flow alignment. Vertical columnar jointing is well developed in much of the rock. Some tuffaceous sediments with perfect feldspar crystals lie below the basalt on the west side of the area, and it is not improbable that the younger tuffs, as well as the later rhyolite of Goldfield, are here associated with the basalt. This rock is probably of late Pliocene or early Pleistocene age.

MONITOR HILLS.

The Monitor Hills are situated in the north-central part of the area surveyed. They are of gentle grade and rise 1,000 feet above the surrounding alluvial slopes.

GENERAL GEOLOGY.

The rocks of the Monitor Hills, the oldest being named first, are granite, Siebert lake beds, rhyolite, and basalt.

SEDIMENTARY ROCKS.

Siebert lake beds.—These hills are in greater portion formed of sandy slopes, from the disintegration of well-bedded tuffaceous sandstones. These are light gray or white in color and usually rather fine-grained, although some faciès are conglomeratic. The rounded pebbles are of light-grayish glassy rhyolite. The tuffaceous sandstones show an apparent exposure of 800 feet. These beds are lithologically similar to and are here correlated with the Siebert lake beds of Tonopah, situated 16 miles north of west of the Monitor Hills. These Spurr[a] considers of Miocene age.

IGNEOUS ROCKS.

Granite.—Angular fragments of a medium-grained siliceous granite occur in the basalt described below, indicating that the basalt in its ascent to the surface passed through a mass of granite.

Rhyolite.—Two isolated hillocks to the south of the main hills appear from a distance to be an igneous rock that is lighter in color than basalt, and that is probably rhyolite.

Basalt.—A number of basalt areas are scattered over the Monitor Hills, and this rock caps the summit of the group. The compact facies has a dense blue-black groundmass which is locally spotted with gray blotches one-fourth inch in diameter. The phenocrysts include light-gray glassy feldspar from one-sixteenth to one-half inch in length. Columns of a dark pyroxene and rounded grains of a glassy black substance, presumably olivine, occur. Under the microscope this rock proves to be a holocrystalline olivine basalt. The black color of the olivine in hand specimens is due to its partial alteration to a blood-red serpentine. Vesicular facies of the basalt are usually reddish brown and scoriaceous facies are brick red. In some beds angular fragments of basalt are embedded in a matrix of similar basalt, forming a flow breccia and showing that motion continued in the lava after some portions had solidified. The more dense facies show spheroidal weathering well developed. Vesicular basalt bounds a central sheet of dense basalt and a ropy surface. The original flow surface is seen at places; this indicates that the larger portion of the basalt is without doubt a flow. The largest mass, however, is probably the site of the vent from which the flows occurred.

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[a] Spurr, J. E., Prof. Paper U. S. Geol. Survey No. 42, 1905, p. 69.

Where the contact between the basalt and the Siebert lake beds is exposed the basalt is seen to lie upon the eroded surface of the sandstone. While it is possible that some masses of basalt on the lower hill slopes are flows contemporaneous with the Siebert lake beds or are later sheets, they are more probably portions of the flow which owe their position partly to the uneven surface of the tuffs and partly to later deformation. The basalt, on structural and lithologic grounds, is believed to be contemporaneous with that of Tonopah, which Spurr[a] believes to be of late Miocene or early Pliocene age.

STRUCTURE.

The Siebert lake beds and the basalt flows are in a broad way horizontal, although they have been tilted slightly to the northeast. The relative distribution of the basalt and the lake beds is such as to suggest that they are cut into a number of blocks by intersecting systems of normal faults.

CACTUS FLAT.

Cactus Flat lies between the Cactus and Kawich ranges. Its center is occupied by a series of playas with north-south trend, which during very exceptional rains merge into one another. They are from 5,330 to 5,350 feet above sea level, and are surrounded by low sand dunes. In this valley the Recent detrital deposits may be thick. The valley from the Cactus to the Kawich Range across Cactus and Gold flats illustrates the steeper slope of valleys near large and high mountain masses and the gentler grade near small and low hills.

GOLD FLAT.

Gold Flat lies between Pahute Mesa and the Cactus and Kawich ranges. Its lowest point, 5,035 feet above sea level, is occupied by a playa, 4 miles west of which, in a small inclosed basin, is another playa. North of the larger playa, at an elevation of 20 to 100 feet above its surface, are a number of round intensely dissected hillocks.

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[a] Spurr, J. E., Prof. Paper U. S. Geol. Survey No. 42, 1905, p. 69.

These hills show a total thickness of 100 feet of white, well-stratified clay, to be correlated with similar playa deposits of the older alluvium in the Stonewall Flat. Presumably this playa deposit and its associated alluvial slope deposits underlie the Recent gravels of Gold Flat at no considerable depth.

KAWICH RANGE.

TOPOGRAPHY AND GEOGRAPHY.

The Kawich Range was named after Chief Kawich, an Indian who lived at the spring at the head of Breen Creek. The range is a southward continuation of the Hot Creek Range, from which it is separated by a narrow transverse valley.[a] From this gap it extends 50 miles southward to a point where it sinks beneath the lava flows of Pahute Mesa. The range has a well-developed crest line with north-south trend. It is deeply indented by valleys at Rose Spring and at Kawich, while 8 miles north of Kawich the Recent alluvial deposits completely arch the range.

In the rugged northern part of the range the sinuous crest line is in many places a knife-edge flanked by high cliffs; south of Rose Spring the topography is much less rugged. From the main crest line subordinate divides of similar character extend at right angles. The crest line at the north edge of the area mapped has an elevation of 9,000 feet, while in the south end of the range it rarely rises above 7,000 feet. Kawich Peak, with an elevation of 9,500 feet, is the highest summit. Quartzite Mountain, a beautiful symmetrical dome southwest of the village of Kawich, is 7,900 feet high.

The Kawich Range is intensely dissected by many stream channels. The drainage line of Little Mill Canyon, which alone is abnormal, courses east 2 miles, bends sharply to the north, and 1 mile below again turns at right angles and resumes its easterly course to the Reveille Valley. A low divide separates the first segment of the stream from a prominent east-west valley in alignment with it south of the mountain southwest of the town of Eden, and it is probable that Little Mill Creek has captured the upper part of its valley.

On the crest line, near the northern boundary of the region shown in the map, are areas of an older and more mature mountain topography, with gentle slopes, in strong contrast with the rugged character of the surrounding ridges and cliffs. Exposures of rock are few and nowhere conspicuous; the surface is covered with soil and supports some grass. This old topography is in advanced maturity or in old age, but the hills existing on its rolling surface are too numerous to call it a peneplain. Remnants of a similar surface are preserved in the Belted, Amargosa, and Panamint ranges, and in the Panamint the surface was developed prior to the outflow of the Pliocene-Pleistocene (?) basalt. This less accentuated surface, which probably extended completely over the area surveyed, is perhaps of early Pliocene age.

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[a] Spurr, J. E., Bull. U. S. Geol. Survey No. 208, 1903, p. 181.

The Kawich Range is rather heavily timbered at its north end above an elevation of 6,500 feet. The timber line becomes higher to the south and neither piñon nor juniper grows south of the detritus-covered gap 8 miles north of the village of Kawich. In consequence of its height and of its rather heavy growth of timber, the Kawich is the best watered range within the area surveyed. The streams of this range have already been described (p. 18). The springs south of the timbered areas are small and some become dry during the summer. The following are rough estimates of the flow of the larger springs in gallons per day: Longstreets Ranch Spring, 3,000 gallons; Stinking Spring, 2,000 gallons; Heenan Water, 1,500 to 2,000 gallons; Rose (sometimes called Wild Horse) Spring, 2,000 gallons; Sumner Spring, 1,500 gallons; Corral Spring, 1,500 gallons; Jarboe Spring, 500 gallons. At Silverbow and Stephanite wells have been sunk in stream gravels and water encountered at depths of 10 to 45 feet.

GENERAL GEOLOGY.

The formations of the Kawich Range, in ascending order, are: Pogonip limestone, Eureka limestone, Lone Mountain limestone, granite, diorite, monzonite porphyry, earlier rhyolite with minor contemporaneous latite and dacite and basalt flows, biotite andesite, dacite, Siebert lake beds (?), later rhyolite, and later basalt and associated andesites.

SEDIMENTARY ROCKS.

Pogonip limestone and Eureka quartzite.—Quartzite Mountain is composed of Paleozoic rocks and from it an arm extends north on the west side of the range and another south on the east side of the range. Small inliers of Paleozoic rocks also occur 2 miles east of Rose Spring, 6 miles west of north of the same point, and 3 miles north of west of Silverbow. Angular fragments of Paleozoic jasperoid, quartzite, and schistose shale are widely distributed in rhyolite, and the vent through which the rhyolites were extruded passed through Paleozoic rocks. Inclusions of Paleozoic rocks also occur in the andesites southeast of Quartzite Mountain.

The sedimentary rocks exposed on Quartzite Mountain consist of 1,200 to 1,500 feet of quartzite underlain by 400 to 600 feet of interbedded quartzites, slaty shales, and limestones. The quartzites of Quartzite Mountain are typically light in color, usually being either white, pinkish white, or gray, although some of the more feldspathic varieties are greenish on account of the development of secondary sericite. Rarely thin laminæ of dark gray or black alternate with the white bands. Pure quartzose facies are more abundant than feldspathic, although well-characterized arkoses also occur. While these rocks are largely quartzites some beds are better defined as indurated sandstones. The rock is typically fine to medium grained, but conglomerates with well-rounded pebbles one-half inch in diameter also occur. The pebbles include smoky or pinkish quartz, probably of granitic origin, pink feldspar, compact red jaspilite, and fine-grained biotite schist with phenocrystic muscovite crystals one-eighth inch long. These pebbles can not be certainly referred to any Paleozoic rocks seen in the area surveyed, although they may possibly be derived in part from the Cambrian or from a pre-Cambrian series. The quartzite is medium to heavily bedded. Cross-bedding is common and ripple marks are locally well developed, while sun cracks are rare and confined to the finer grained arkoses. The quartzite is well cemented and both pebbles and matrix are cut by numerous quartz veinlets. The presence of two intersecting systems of quartz veins at an angle of 45° to the bedding planes, one set short and rather wide in the plane of stretching, the other thin, more numerous, and of greater length in the plane of compression, indicates that the quartzite beds have suffered considerable shearing. Muscovite films have been developed on some parting planes. Minor faults occur in the quartzite mass and in some cases cut the quartz veins. Joints are well developed and in consequence the rock fragments are angular blocks.

The rugged inlier of quartzite 3 miles north of east of Silverbow is surrounded by rhyolite. It is similar lithologically to the purer white or pinkish-white quartzites of Quartzite Mountain. Thin quartz veins with vugs and a few seams of pyrite cut it. The quartzite area 6 miles west of north of Rose Spring exposes 400 feet of similar quartzite. Conglomeratic bands with white quartz pebbles one-half inch in diameter are interbedded with the fine-grained bands.

The slaty shale of Quartzite Mountain grades on the one hand into argillaceous sandstone and on the other into clayey limestone. The shale is fine grained and olive green or dark gray in color, although in rare instances bright-green facies occur through the development of chlorite. Secondary mica films are common on the shale parting planes.

The limestone of the Quartzite Mountain section is a siliceous, compact, well-bedded rock of medium grain. In color it is yellow or reddish yellow. Some beds are oolitic, with white calcite cement which over areas one-half inch in diameter is of common orientation and reflects light like a single cleavage face. The texture is the poikilitic of igneous rocks. Suture joints occur, but are not characteristic. In the small area of sedimentary rocks 2 miles east of

Rose Spring finely banded, dark-colored silicified limestone similar to that of the Southern Klondike hills outcrops, and this, while probably Ordovician, may possibly be a Cambrian inlier.

The rocks of Quartzite Mountain appear to have been laid down in a shallow sea. At some periods during the deposition of the lower portion the sea received fragmental material, both fine and medium grained; at others it received but little, in consequence permitting the deposition of limestone. The presence of sun cracks indicates that at times the deposits were even above sea level. The main quartzite mass was deposited in a shallow sea to which medium to coarse fragmental material was rather constantly supplied.

The rocks beneath the quartzite of Quartzite Mountain resemble the interbedded quartzites, slaty shales, and limestones which overlie the Pogonip limestone of the Belted Range. In consequence the lower rocks of Quartzite Mountain are probably the transitional beds of the Pogonip limestone, while the quartzite, notwithstanding its unusual thickness, is the Eureka quartzite.

Lone Mountain limestone.—A small limestone hill protrudes from the Recent detrital deposits 7½ miles south of east of Rose Spring. Mr. T. C. Spaulding collected a specimen which proves to be a gray crystalline limestone with numerous calcite veins. If the structure of the Paleozoic rocks extending northward from Quartzite Mountain beneath the rhyolite of the Kawich Range continues its easterly dip, this limestone lies above the Eureka quartzite and is probably the Lone Mountain limestone of the Eureka section, described by Hague.

Siebert lake beds (?).—Lying unconformably upon the earlier rhyolite and in one case apparently unconformably below the later rhyolite are a number of small exposures of rhyolitic sandstone, usually conglomeratic. These slightly consolidated sandstones are white, gray, or greenish in color and are distinctly bedded. The well-rounded pebbles and bowlders, the larger of which are 1 foot in diameter, include Paleozoic quartzites and jasperoids, granites, diorite porphyry, monzonite porphyry, and the earlier rhyolite. Quartz, feldspar, and biotite crystals are characteristic, and either explosive eruptions of rhyolite occurred during the deposition of these sandstones or the crystals were derived from rhyolites with incoherent groundmasses. The more easterly of the two masses mapped 3 miles north of Kawich is a bedded conglomerate cemented by chalcedony. The conglomerate is better assorted than that of the rhyolitic sandstone and resembles the well-rounded conglomerates of the Amargosa Range. It is certainly younger than the earlier rhyolite, since it carries rhyolite bowlders and is perhaps contemporaneous with the Siebert lake beds.

Spurr[a] found similar rhyolitic sandstones 600 feet thick at the north end of the Reveille Range. If the correlation of the earlier rhyolite with the Tonopah rhyolite-dacite is correct, these beds are probably the Siebert lake beds, of Miocene age. The last-mentioned exposure may, like the conglomerates of the Grapevine Range, be a shore deposit of this lake.

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[a] Spurr, J. E., Bull. U. S. Geol. Survey No. 208, 1903, p. 163.

IGNEOUS ROCKS.

Post-Jurassic granite.—One mile west of Sumner Spring is an outcrop of gray granite porphyry with a dense groundmass containing many phenocrysts of feldspar three-fourths of an inch in length and rounded quartz individuals one-fourth inch in diameter. Under the microscope the groundmass shows as a fine mosaic of quartz and orthoclase with a little plagioclase. With the phenocrysts of orthoclase and embayed quartz are some of plagioclase and very small tablets of biotite altered to muscovite and a rutilelike substance. Apatite, zircon, and magnetite are accessory minerals. The relations of this mass to the earlier rhyolite are poorly exposed, but on lithologic grounds it is considered a post-Jurassic granite porphyry.

Granite inclusions in rhyolite were observed at five widely separated localities. The varieties include fine- or medium-grained biotite granites, coarse-grained muscovite granite, pegmatitic quartz, and biotite granite with porphyritic feldspar crystals similar to the granite of Lone Mountain. Large bowlders of medium-grained biotite granite are so abundant in the Siebert lake beds 4 miles east of north of Silverbow that a granite outcrop was probably near at hand when the sandstone was deposited.

Diorite porphyry.—Bowlders of diorite porphyry are associated with those of granite in the area of Siebert lake beds just mentioned. The rock has a white, finely crystalline groundmass, in which are embedded numerous white striated feldspar phenocrysts with a maximum length of one-fourth inch and smaller biotite phenocrysts. The rock is similar to the diorite porphyry of the Lone Mountain foothills and is probably a later manifestation of the post-Jurassic granite intrusion.

Monzonite porphyry.—Monzonite porphyry occupies an area 4 miles long and 3 miles wide west of Kawich. It has a fine-grained dark or medium-gray groundmass, in which are embedded abundant phenocrysts, many one-fourth inch, a few one-half inch long, of white or greenish-white striated feldspar. brown biotite, and altered hornblende. While both hornblende and biotite are usually present the relative porportion of the two varies widely throughout the area. Oxidation of the iron of the rock produces pink and purple varieties, while kaolinization gives a white color.

Microscopic examination shows the groundmass to be a medium-grained interlocking mosaic of orthoclase and plagioclase. Plagioclase phenocrysts, which are more abundant than those of hornblende or biotite, are usually complex crystals showing albite and, less commonly, Carlsbad and pericline twinning. Zonal growth is rather common. The plagioclase is slightly altered to calcite, zoisite, sericite, and chlorite. Biotite is altered to chlorite, calcite, magnetite, titanite, and epidote. Areas of chlorite, epidote, calcite, and quartz rudely preserve hornblende forms, while a little fresh brown hornblende is present.

Dikes of monzonite porphyry cut the Paleozoic sediments and the main mass is probably an eroded stock. The outcrops of monzonite porphyry are cut by rather closely spaced joints and in consequence break down into angular blocks. Spheroidal weathering is here and there poorly developed.

The monzonite porphyry in places appears to lie upon the eroded edges of the Paleozoic sedimentary rocks and inclusions of monzonite porphyry occur in the rhyolite on its northern border. This rock is rather similar to the biotite-hornblende latite of the Cactus Range and more closely resembles the quartz-monzonite porphyry of Stonewall, Shoshone, and Skull mountains. These rocks are in a broad way contemporaneous and of late Eocene age.

Earlier rhyolite.—Earlier rhyolite with associated latite and dacite forms most of the mountain range north of an east-west line 2 miles north of Kawich. Small areas occur south of this line and in the Reveille Valley. The rhyolite south of Rose Spring and on the flanks of the range north of this point is unquestionably a flow. The crest of the range north of Rose Spring is composed of compact rhyolite, in which flow bedding is absent or very obscure. It is probable that the crest in part or as a whole lies upon the fissure from which the rock was extruded. Some of the masses of rhyolite in the vicinity of Kawich are perhaps dikes intruded in the monzonite porphyry, and the poorly exposed rhyolite in the Paleozoic quartzite 6½ miles west of north of Rose Spring may also be a dike.

These acidic rocks include many facies. Perhaps the predominant type is a reddish rhyolite with compact flinty groundmass, containing abundant medium-sized phenocrysts of glassy orthoclase and slightly smoky quartz, with fewer and smaller phenocrysts of black mica, which in some instances are absent. The quartz phenocrysts are, as a rule, rounded crystals and only a few show the dihexagonal pyramid and prism. Other rhyolites are gray or brown in color, while some black glasses with the normal phenocrysts also occur. In the more glassy types flow lines, spherulites, and perlitic parting are common. The microscope shows the groundmass of the rhyolite to be of turbid brown glass, in which flow lines and spherulites are well developed locally. The phenocrysts are in some instances well formed and in others are angular fragments, showing that flow continued while the lava was very viscous. Biotite is fairly abundant in some slides, while in others it is represented by ill-defined pseudomorphs.

Quartz latites are widely interbedded with the rhyolites, being particularly well exposed at Stinking Spring. They are characterized in the hand specimen by the presence of phenocrysts of both striated and unstriated feldspar and a hornblende-like mineral which reaches a maximum length of one-fourth inch. Microscopic examination shows a glassy groundmass containing as phenocrysts quartz, orthoclase, plagioclase, and hornblende or augite. Both feldspars are often zonally built. Magnetite and apatite are common accessories.

Brown glassy dacites are less widely distributed. Microscopic examination shows a rock similar to the quartz latite, except that plagioclase is present to the almost total exclusion of orthoclase, and ilmenite accompanies magnetite.

Many beds of the acidic series are flow breccias, including angular fragments of texturally similar or dissimilar acidic rocks, indicating that portions of the flow solidified prior to the cessation of movement in other parts. White, slightly porous pieces of rhyolitic glass, elongated in the direction of flow, are common in certain areas. Similar inclusions characterize the earlier rhyolite of Goldfield and the rhyolite of Bullfrog.

About 1½ miles east of Rose Spring is an area of consolidated white shaly sandstones and coarse, well-bedded sandstones. The microscope shows that the rock is a typical tuffaceous sandstone of rhyolitic composition. It was probably deposited in a small body of water contemporaneous with the outflow of the earlier rhyolite.

The acidic series imparts to the Kawich Range a white, yellow, or red color, and in places all these are distributed in broad bands either horizontally or slightly tilted. Spires are developed on canyon walls in jointed rhyolite, the same rock forming rounded bosses in the broader, more mature valleys. South of the detrital gap in the range the hills have a marked northwest-southeast alignment parallel to the strike of resistant rhyolite flow bands.

The earlier rhyolite of the Kawich Range lies below supposed Siebert lake beds and is similar to and probably contemporaneous with the rhyolite of the Belted, Cactus, and Reveille ranges and the Bullfrog Hills. In a general way the series is comparable with the pre-Siebert rhyolites and dacites of the Tonopah district,[a] which are probably of early Miocene age.

Earlier basalt.—Minor flows of basalt were extruded contemporaneously with the earlier rhyolite. The small mass of dense black basalt with sparse, medium-sized, glassy feldspar phenocrysts three-fourths of a mile east of Silverbow is probably such flow. This rock on microscopic examination proves to be a holocrystalline olivine- and augite-bearing basalt, somewhat altered. Orthoclase phenocrysts are also present. Small inclusions of vesicular basalt occur in rhyolite 1½ miles north of Silverbow. Basaltic flows contemporaneous with rhyolite also occur in the Amargosa Range and the Bullfrog Hills.

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[a] Spurr, J. E., Prof. Paper U. S. Geol. Survey No. 42, 1905, pp. 37–43.

Biotite andesite.—One mile northwest of Silverbow a small hill surrounded by alluvium is composed of a fine-grained dense andesite of gray color. The small phenocrysts, which are in rude flow orientation, consist of white striated feldspars and more numerous smaller biotites. Southeast of Blakes Camp is a poorly exposed mass of a greenish-gray andesitic rock, considerably altered. Biotite and striated feldspars one-eighth inch long are equally abundant. Under the microscope the glassy groundmass is seen to be subordinate to the phenocrysts, which consist of medium-sized simple crystals of plagioclase, biotite, and a few deeply embayed orthoclase individuals. The plagioclase is considerably altered to calcite, and the sericite and the biotite to chlorite. It is probable that these two exposures are to be correlated with one another and with the biotite-andesite intrusive in the rhyolite of the Cactus Range.

Dacite.—In the vicinity of Rose Spring are five small areas of dacite. Another small mass lies 1 mile east of Stinking Spring and a rather similar rock is exposed 3 miles south of Georges Water. The dacite has a compact aphanitic groundmass of medium to dark-gray or brown color. The phenocrysts equal the groundmass in bulk, and consist of medium-sized glassy striated feldspars, hornblende, mica, and quartz. The quartz, while not abundant, is constantly present. A few well-formed crystals of striated feldspar, evidently of a later origin than those just mentioned, are from three-fourths of an inch to 1½ inches long. These are white or gray in color and include tiny biotite plates and hornblende columns. Weathering brings out clearly the zonal structure, while Carlsbad twins are sometimes seen. The phenocrysts near contacts with older rocks possess a parallel flow orientation. Microscopic examination shows the rock to have a felty groundmass of plagioclase laths with a few orthoclase and quartz grains. Many of the smaller plagioclase phenocrysts, which are usually compound and slightly rounded by magmatic corrosion, show beautiful zonal growth. Plagioclase is ordinarily fresh, although calcite is locally developed from it. One or more quartz phenocrysts deeply embayed are present in most of the thin sections. Biotite, usually surrounded by a magnetite reaction rim, is abundant. Forms characteristic of hornblende and heavily rimmed by magnetite grains are completely altered, calcite, in places accompanied by serpentine, and magnetite being the alteration products. Magnetite and apatite are accessory minerals. The dacite occurs in dikes and irregular intrusive masses which cut the earlier rhyolite 2 miles southwest of Sumner Spring. The mass 1½ miles east of Rose Spring is intrusive in shaly sediments that are probably interbedded with the earlier rhyolite. This dacite is lithologically identical with the dacite of the Goldfield hills and the two are probably contemporaneous and of middle Miocene age.

Later rhyolite.—Forming the gently sloping flanks of the range west of Silverbow and capping some of the hills to the south of the same village is a brown, dense, and in many places glassy rhyolite characteristically poor in biotite and rich in quartz phenocrysts. Vesicles, elongated parallel to the flow banding, and vertical joints of cooling occur. In some places this rhyolite apparently lies upon the slightly eroded surface of the earlier rhyolite, and 5 miles south of Blakes Camp it appears, at a distance, to overlie the Siebert lake beds. The later rock has suffered much less erosion than the earlier rhyolite. The rock, so far as seen, was not altered by the mineralizing waters which formed the ore deposits. This rhyolite is younger than the supposed Siebert lake beds and is perhaps about contemporaneous with the later rhyolite of the Belted Range.

Later basalt and associated andesites.—Basalt caps the Kawich Range south of Quartzite Mountain. A number of basalt hills outcrop in the Reveille Valley, and on the east side of the range are a number of low buttes partly of the same rock. The basalt of the south end of the range is black, dense, and more or less vesicular. The cone on the east flank of the mountains 10 miles east of north of Kawich is composed of a similar rock, in which a few small feldspar laths are the only conspicuous phenocrysts. Olivine basalts occur in the Reveille Valley. Basalt also forms a mesa 5 miles west of Silverbow. Andesite is associated with some of the basalt. The andesitic rocks of the Reveille Valley have a dense mottled reddish-gray or lilac-gray groundmass, which is locally vesicular. The medium-sized phenocrysts, which equal the base in mass, include glassy striated feldspar laths, many of which are twinned according to the Carlsbad law; fewer biotite plates, and hornblende or pyroxene columns. Spheroidal weathering is rather characteristic. Flow breccias occur in bands, and the rock appears to be closely related to the associated basalts, each partially burying the small earlier rhyolite outcrop. A similar rock, although practically lacking biotite, forms a number of low, flat-topped hills 6 miles south of Kawich. Phenocrysts are abundant in some facies and in others lacking. The rock occurs in flows which dip to the east. The hill 6 miles N. 30° E. of Kawich is capped by vesicular basalt beneath which are gray andesitic rocks with glassy striated feldspar phenocrysts up to one-fourth inch in diameter.

The basalt is similar to that of the Belted and Reveille ranges and is probably of late Pliocene or early Pleistocene age. The andesites are doubtless earlier manifestations of the same periods of volcanism.

STRUCTURE.

The Paleozoic rocks are complexly folded (see fig. 8). The Quartzite Mountain section is a north-south monocline with dips of 10° to 30° E. The Paleozoic rocks on the west side of the Belted Range dip to the east, and the Kawich Valley probably overlies a gentle syncline, although the structure may be much more complex. The vertical strata of the inlier 3 miles north of east of Silverbow strike east and west. The quartzite 6 miles west of north of Rose Spring strikes N. 75° W. and dips 45° S. Zones of brecciation, indicating that this pre-Tertiary folding was accompanied with some faulting, are not unusual. The presence in the volcanic rocks of Paleozoic inliers proves that prior to the inauguration of the Tertiary volcanism the Paleozoic rocks of the Kawich Range had a diversified topography. The mountain range then may have been as rugged as now, since the valleys on either side were doubtless at lower levels than at present.

It is unknown whether or not the normal faults in the monzonite porphyry at Kawich, which are in part older and in part younger than the ore deposits, were formed prior to the outflow of the rhyolite.

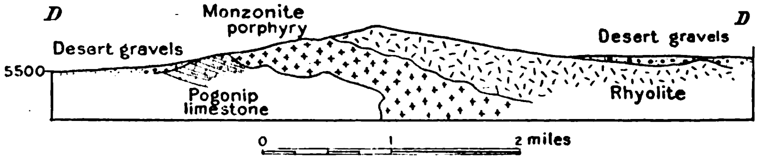

FIG. 8.—East-west section across Kawich Range 2½ miles north of Kawich.

The rhyolite series north of Rose Spring is a monocline with north-south strike and low easterly dip. Minor folds of similar strike are superimposed upon the monocline. At the detrital gap the strike changes to northwest with a dip of 10° to 20° NE. This uplift occurred after the deposition of the Siebert lake beds, since they lie on the very crest of the range. Joints were developed in the rhyolite contemporaneously with the folding. Sheeting parallel to the folds is rather characteristic, although cross joints occur. After the outflow of the basalt the range was uplifted, as is shown by the fact that the flows southeast of Quartzite Mountain have a decided dip to the east. An undetermined amount of normal faulting accompanied the post-rhyolitic elevation, and in certain areas, notably in the shales associated with the rhyolite 1½ miles east of Rose Spring, the faulting is very complex.

ECONOMIC GEOLOGY.

Mining activity in the Kawich Range centers in three major camps—Silverbow, Kawich, and Eden—and in two minor camps—Blakes Camp and Southern Kawich.

SILVERBOW.

Silverbow is situated in the cañon of Breen Creek, on the west side of Kawich Range, 43 miles north of east of Goldfield. The principal prospects are within 3 miles to the east, northeast, and northwest of the village. The first locations were made in November, 1904. When visited by the writer (July 20, 1905) Silverbow was the supply center for several hundred men, and a number of shallow prospect holes had been sunk.

The ore deposits lie in rhyolite, which in the vicinity of veins is either kaolinized or silicified, the silicification being perhaps more common. (See p. 47.) Either type may be intensely stained red, brown, or yellow by iron oxides.

The more important prospects are located on parallel quartz veins or lenses, which widen, thin, and in places give out, forming mineralized bands whose strike in the district is in many cases north of west. The individual quartz veins vary in width from a fraction of an inch to 5 feet, and many of these are connected by minor cross veins. While in some instances the quartz was deposited along premineral faults, in others it occurs along joints, which locally form intersecting systems. Quartz likewise fills many of the spaces caused by brecciation and forms in solution cavities in the rhyolite. The quartz is, as a rule, white and translucent or colorless and transparent, although in the Blazier tunnel a single vein of amethyst-purple color was noted. A thin section of quartz from the Wheaton and McGonagill prospects is a quartz mosaic of very uneven grain. In the mosaic are zonally grown crystals of quartz, and finely divided silver sulphides dust some of the bands of growth. The borders of these quartz crystals appear to be formed of quartz fibers, radiating from the center. Crystal-lined vugs are common in this vein quartz, and crustification is beautifully developed in many specimens, fortification, agate, and mammillary forms being common.

The quartz is more or less stained by iron salts, rarely by malachite. In the quartz specks of stephanite, ruby silver, silver chloride, and probably other silver ores occur. The silver chloride is at least a secondary mineral and to a limited extent is disseminated in the country rock. Gold occurs free. Silver is the predominant metal, and $1 in gold to $3 in silver is perhaps an average for the whole camp, although in some prospects the silver values are 20 times those of gold. The ore runs from $6 to $250 per ton, though some reports give higher values. Since the writer's visit strikes in which gold predominates over silver have been reported. Rarely values occur in limonite stringers in the country rock, while in several prospects a greasy crushed rhyolite constitutes the ore.

The striking similarity between the ore deposits of Silverbow and certain of those of Goldfield is worthy of note. Ascending water carrying silica and metallic salts in solution appears to have deposited its burden largely in preexisting cavities. Simultaneously waters wandering from the main channels silicified contiguous portions of the rhyolite. Kaolinization is presumably a later phenomenon. Movement has occurred in the veins since silicification, and they have been more or less faulted and brecciated. Surface waters have altered silver sulphides, pyrite, and probably less amounts of chalcopyrite to the corresponding chloride, oxides, and carbonates, while secondary sulphides have also been formed. Gold, probably originally in pyrite, was simultaneously set free.

Timber and water are abundant near the mines. Goldfield is about 50 miles distant by road.

BLAKES CAMP.

Blakes Camp is located on one of the earlier rhyolite inliers which protrude from the " wash " 12 miles northwest of Silverbow. The prospect was discovered late in June, 1905. A fault with well-defined walls coursing N. 80° E. cuts the rhyolite, and in its immediate vicinity the country rock is silicified. Along this fault for a distance of 600 feet a zone from 18 to 24 inches wide is crushed to a fine clay, in which are embedded slickensided fragments. The ground-up rhyolite is white or stained by hematite or limonite and to a less extent by manganese dioxide. This material is said to pan about $15 per ton of free gold. Quartz veins in rhyolite north and east of Blakes Camp are said to carry both gold and silver.

EDEN.

The mining camp of Eden is situated near the mouth of Little Mill Creek Canyon, on the east side of the Kawich Range. The first locations were made February 20, 1905, by John Adams.

Three distinct vertical zones of mineralization cross Little Mill Creek from north-northeast to south-southwest, respectively, one-fourth, one-half, and five-eighths mile above the old mill at the road forks. The country rock is rhyolite, which in many places is intensely silicified parallel to the mineralized zones. While the contact between the silicified and the unsilicified rhyolite is as a rule rather sharp, in some places there is transition. The quartz and silicified rhyolite stand out in distinct walls, aptly called by the miners " dikes," which follow the mineralized zones.

The central zone has been more developed than the others and was studied in more detail. This zone is situated along a line of faulting and brecciation and the rhyolite near the zone is mashed. The mineralized zone varies from a vein of quartz 3 feet wide with a few rhyolite horses to a band of silicified rhyolite 8 feet wide, intensely netted by quartz stringers. Parallel quartz veins more or less continuous and connected by cross veins are transitional between the two forms along the strike. The quartz, much of it crustified, is white and more or less iron stained. Finely divided sulphides impart a blue tinge to some of the quartz, and the parallel position in thin bands of the white and blue quartz shows clearly the contemporaneous origin of the quartz and sulphides. Vugs, usually elongated, parallel to the walls of the veins, are characteristic. Colorless quartz crystals are common in these vugs, while botryoidal quartz walls are less common. The vein in some portions is composed of clusters of quartz plates an inch in length set at right angles to the vein walls. These suggest that the quartz in parts is a replacement of calcite. The normal crystalline quartz grades into a compact white flinty variety, which is said to be a good carrier of gold. Under the microscope this appears as a cryptocrystalline mosaic of quartz with a little sericite. This central zone is a silver bearer, the gold values being one-tenth those of silver. As silver ores, ruby, and native silver are reported intimately associated, secondary silver chloride in knobs and wire-like masses is widely distributed in the vugs, and the silicified rhyolite itself carries values. Iron sulphide was noted in a few small specks in quartz vein.

The upper zone of mineralization is said to be very similar to the central zone. The lower zone is also similar to the central, although there is perhaps less parallelism and constancy of the quartz veins. The strike is more northerly. Pyrite locally impregnates the rhyolite. The flinty quartz already mentioned is abundant in this ledge, and the values are largely gold. The resemblance of the Eden deposits to those of Silverbow is striking, and the genesis was doubtless similar and contemporaneous.

Water and fuel are abundant. Tonopah, the supply depot, is 70 miles distant.

KAWICH.

Kawich, in the Gold Reed mining district, lies in a detrital embayment on the east side of the Kawich Range. The town is 54 miles south of east of Goldfield. The first locations were made in December, 1904, and early in the spring of 1905 several hundred men rushed to the camp. When visited (August 4, 1905) 10 miners were at work. Two shafts have been sunk 150 feet and several thousand feet of drifts have been driven. The mines are situated on a gently sloping area of wash, from which protrude numerous small rugged knobs of monzonite porphyry and smooth domes of rhyolite. The monzonite porphyry has so far been the ore bearer.

The first locations were made on the property of the Gold Reed Mining Company. Here a rugged outcrop of intensely silicified monzonite porphyry, dark brown on weathered surfaces, contains in the limonite-stained casts of its many phenocrysts plates of hackly gold, some of which are an inch in diameter. This altered rock has a conchoidal fracture. The microscope shows the rock to be composed of interlocking quartz grains in which there is some finely divided material, possibly of a clayey nature. The areas once occupied by feldspar phenocrysts contain a slightly higher percentage of this turbid substance, while some sagenitic webs of rutile indicate the former presence of biotite. Associated with the silicified porphyry are white kaolinized facies which are locally stained red or purplish by iron oxides. Numerous other areas of silicified porphyry have been located by prospectors, but at none was gold visible to the eye, although many panned gold. The boundary between the silicified and unsilicified porphyry is usually sharp. Strong iron stains and some dendrites of manganese dioxide are associated with the gold. The iron stains probably point to pyrite as the original source of the ore, an inference strengthened by the presence of gypsum. This mineral is rather closely associated with the ore, in some places filling cavities in it and in others filling joint and fracture planes in the country rock. The gypsum occurring in the country rock is fibrous, the fibers being set at right angles to the walls. The residual soil near ore deposits is locally cemented by gypsum. Gypsum was probably formed by the interaction of iron sulphate, set free by the oxidation of pyrite, and of calcium-bearing solutions derived from the decomposition of the plagioclase of the monzonite porphyry. Quartz veinlets cut the silicified porphyry, but these are reported to carry no values. Certain clear phenocryst-like quartz areas indicate that silicification continued after the removal of the phenocrysts usual in monzonite porphyry. In the deepest shafts the silicified porphyry holds its width, although up to the time of this examination the values were low except at the surface. At the Gold Reed mine good values have been obtained in a kaolinitic substance found in the cavities of the silicified porphyry at the 100-foot level.

Iron pyrite has been encountered on the 150-foot level at the Gold Reed mine, disseminated in unsilicified monzonite porphyry. Its assay value is low. Several thin veins of pyrite occur on the lower levels of the Diamond No. 2. These veins are banded and vugs occur here and there in the center. This pyrite is said to assay $35 in gold per ton.

The silicified monzonite porphyry has been considerably faulted and slickensides and breccias are common. At the Gold Reed mine the faulting has been very complex, and wedge-shaped cavities, which reach a maximum length of 5 feet, appear to be due to faulting. At the Chief Kawich mine the faults strike N. 50° W., parallel to the silicified-porphyry boundary, and dip 80° SW. At the Diamond No. 2 the faults dip 45° E. The step-like offsets in the silicified porphyry on which the Chief Kawich and the Gold Reed mines are situated are rather suggestive of faulting, although the effect may be due to a chance distribution of several small masses of silicified porphyry.

The resemblance between the Kawich and Gold Crater deposits is close. It is probable that waters bearing silica in solution arose along joint and fault planes and that silica more or less completely replaced the rock contiguous to the fractures. Pyrite was probably simultaneously deposited, partly in the country rock and partly in open fissures. Since the silicification the veins have been faulted. The kaolinization of certain portions of the porphyry was probably contemporaneous with the surface alteration of the original sulphides. From the lean character of the pyrite so far encountered it is probable that the rich surface gold deposits have been concentrated from the pyrite contained in many feet of porphyry which have been removed by erosion, but it is by no means impossible that rich pockets of gold may be found from time to time near the surface.

Water is obtained at Cliff Spring, 12 miles east of the settlement, and piñon grows on the Kawich Range 8 miles to the north. Tonopah is 70 miles distant by road.

SOUTHERN KAWICH.

In the blue-black Pogonip limestone on the northwest slope of Twin Peaks, 6 miles south of Kawich, prospects are located on a quartz vein 1½ feet thick. The quartz is strongly stained by limonite and is said to carry free gold.

AREAS FAVORABLE TO PROSPECTING.

The areas noted in the progress of work in which occur altered rocks of the same character as those which accompany the ore deposits at the camps already described are shown in fig. 4. Other areas of similarly altered rock doubtless exist, although it is believed that the largest are mapped. Of the rhyolite areas shown those near Silverbow and Eden and east of Blakes Camp contain an unusual number of quartz veins. The monzonite porphyry in which the ore deposits of Kawich occur is confined to the immediate vicinity of the town. The areas of altered monzonite porphyry have already been located and the future of this form of ore deposits depends on the development of these areas.

Quartz veins occur in the Paleozoic sedimentary rocks, particularly in quartzite. So far as seen these veins are narrow and of no great length, and with the exception of the Southern Kawich veins the quartz is apparently barren. Quartz veins, probably barren, on the western side of Quartzite Mountain contain tablets of specular hematite.

REVEILLE VALLEY.

Reveille Valley lies between the Kawich and Reveille ranges. The depression is separated into two parts by a low gravel divide north of its center, the northern portion draining northward and the southern portion draining southeastward into Railroad Valley. The Recent gravels are probably nowhere thick in Reveille Valley. Basalt flows underlie much of the area and form hills in the valleys and scarps along the drain line. Fig. 9 is a section across the valley, drawn north of west to the Kawich Range from a point on the Reveille Range 6 miles north of Reveille Peak. A single mass of early Miocene rhyolite is exposed beneath the basalt northeast of Sumner Spring.

KAWICH VALLEY.

The Kawich Valley lies between the Kawich and Belted ranges. It is separated from Railroad Valley to the northeast by a low gravel divide and from Reveille Valley to the north by hills of basalt. Kawich Valley is notable for its even grade, since the mountains on either side have approximately an equal elevation and mass. Its playas lie at an elevation of about 5,300 feet above sea level. A few rounded exposures of older alluvium lie 20 feet above the small playa on the road from Kawich to Indian Spring. These are similar to those of Gold Flat.

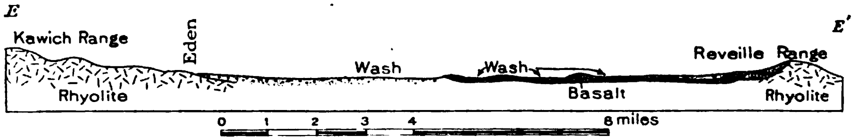

FIG. 9.—Section across north end of Reveille Valley, showing an inclosed valley partially underlain by basalt.

REVEILLE RANGE.

TOPOGRAPHY AND GEOGRAPHY.

The Reveille Range is separated from the Pancake Range on the north by a narrow transverse gap and from the Belted Range on the south by Railroad Valley. In former descriptions and in the parlance of prospectors the Reveille and the Belted ranges are merged into one, the name Reveille being applied not only to that range itself but also to the north end of the Belted Range. As here defined, each range is a unit, separated by a transverse valley from 2,500 to 3,000 feet below the crest line of the ranges. These two north-south ranges are, however, aligned, and the structure of the Paleozoic rocks indicates that prior to the long period of erosion which preceded the Tertiary volcanism they were connected.

The Reveille is a narrow, rugged mountain range with a crest line of rather sharp peaks culminating near its south end in Reveille Peak, 8,900 feet high. The eastern slope, descending to the deep Railroad Valley, is the more precipitous. The crest line against which deep, narrow canyons head, is in places a knife-edge flanked on either side by cliffs hundreds of feet high. The more profound of these canyons are 1,000 feet deep and are notable for the forests of rhyolite spires which cover their precipitous sides. The rhyolite is everywhere characterized by a rugged topography. Fang Ridge is a prominent part of the range from which protrude fantastic domes and spires strikingly like the fangs and molar teeth of an ancient monster. The " teeth " are from 200 to 300 feet high. The smooth slopes and shallow, straight-walled canyons of the flanking masses of basalt, which in some cases almost bridge over the range, are in strong contrast with the intensely dissected rhyolite.

The crest line of the range is covered by a fair growth of piñon and juniper, which at the northern border of the area surveyed on the west side descend to the alluvial slopes. Several large springs are located at Old Reveille, 1½ miles north of the boundary of this area, and a pipe line extends from these to New Reveille.

GENERAL GEOLOGY.

The formations of the Reveille Range include, in ascending order, the Weber conglomerate, Pennsylvanian limestone, rhyolite, and basalt.

SEDIMENTARY ROCKS.

Weber conglomerate.—North of the area mapped from Old Reveille to the summit, between that town and New Reveille, the predominant formation is a white massive quartzite, of which from 1,000 to 2,000 feet is exposed. If, as is apparently the case, this quartzite underlies the Pennsylvanian limestone it is the Weber conglomerate, although lithologically it is more nearly related to the Prospect Mountain (Cambrian) or Eureka (Silurian) quartzite.

Pennsylvanian limestone.—Overlying this quartzite, apparently conformably on the west side of the range near Reveille, is 2,000 feet or more of dark-gray to black compact, massively bedded limestone. With it are associated bands of black flint and thin beds of argillaceous limestone. The limestone is cut in every direction by veinlets of calcite. The formation is similar to the Pennsylvanian limestone of the Belted Range, and poorly preserved fossils from a bowlder near New Reveille are considered by Dr. George H. Girty to be probably of Pennsylvanian age. Inclusions of flint are common in the rhyolite, described in the following paragraphs, near its contact with the Paleozoic rocks.

IGNEOUS ROCKS.

Rhyolite.—The major portion of the Reveille Range is composed of rhyolite, which has a flinty, glassy groundmass, flow banding being common. Gray and pink are the predominant colors, although red, black, and brown are not unusual. Phenocrysts are abundant and equal the base in mass. Colorless or smoky quartz and glassy feldspar phenocrysts of medium size predominate over the smaller individuals of biotite. Weathered surfaces show feldspar whitened or represented by casts, biotite flush with the surface, and quartz in relief. Thin sections under the microscope present a brown, glassy groundmass, exhibiting well-defined flow flexures, and over small areas a spherulitic structure. A small portion of the feldspar is an acidic plagioclase, while many of the biotite phenocrysts were bent prior to the solidification of the lava. Magnetite, zircon, and apatite are also present.

The rhyolite is a series of flows, and in consequence over large areas it weathers like a well-bedded sedimentary rock, a resemblance magnified by the presence of a north-south sheeting. Vertical joints are locally present, and where flow banding is not prominent the rhyolite weathers into spires from 30 to 150 feet high and from 5 to 25 feet in diameter. In places these are single and spring from a common base. Where no parting planes are prominent the rhyolite displays the well-rounded domes and bosses characteristic of a granite country.

The rhyolite of the Reveille Range is similar lithologically to that of the Kawich Range and has suffered equal deformation and erosion. The two are doubtless contemporaneous in age and are probably early Miocene.

Basalt.—Lying upon the rhyolite are basalt flows which usually occur flanking the range, but in one case extend from the eastern base across the crest line. The flows were once much more extensive and perhaps completely covered the range 4 miles north of Reveille Peak. Basalt also forms isolated hills in the alluvial deposits. As shown in fig. 9, these are probably connected with flows on the flanks of the range. The basalt varies from a dense black rock to a vesicular slag of red color. The vesicles reach a maximum diameter of 1 inch and are elongated in the plane of flow. The phenocrysts are subordinate in bulk to the groundmass, and include conspicuous gray or white striated feldspar laths up to three-fourths of an inch long, rather obscure yellow altered olivines, and black pyroxene columns. Weathered basalt breaks down into spheroidal masses surrounded by thin concentric shells.

On microscopic examination the rock proves to be an augite-olivine basalt with glassy base. Abundant plagioclase laths, fewer augite crystals, rounded olivines, and magnetites are the phenocrysts.

The basalt is similar lithologically to the later basalt and is probably of Pliocene age, since the amount of erosion suffered renders its effusion in Pleistocene time improbable.

STRUCTURE.

The Paleozoic rocks are folded into a monocline striking north and south and dipping 15° to 30° W., but a corresponding eastward dipping arm of an anticline may be covered by the rhyolite of the eastern side of the range. Minor faults are present. Prior to the effusion of the rhyolite the rocks formed a rugged mountain range. (See fig. 10.) After the outflow of the rhyolite the range was subjected to orogenic movements, the compressive force acting from the east or the west, and the mountains were again uplifted, the rhyolite was slightly crumpled, and a north-south sheeting was produced. When the basalt flowed out the range was rugged and probably approximately as high as at present. The small peak of rhyolite surrounded by basalt 6 miles west of north of Reveille Peak was probably never completely covered by basalt. A decided thickening of the basalt occurs at the base of the mountains, but the dip of the flow surface, in places 15° to 18°, is probably in part due to recent uplifts of the range. The vent from which the basalt was extruded was probably near the crest of the range 7 miles north of Reveille Peak.

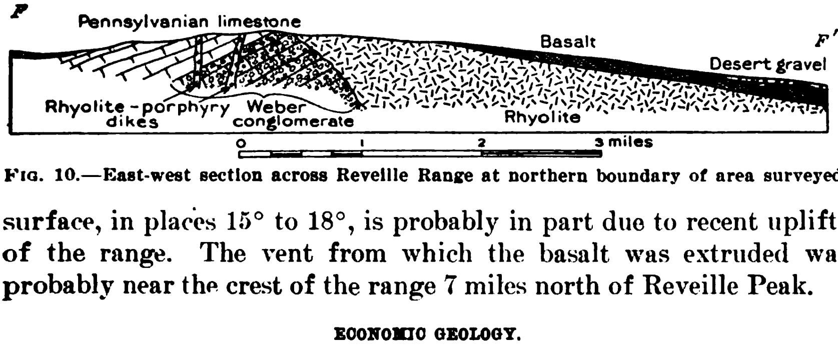

FIG. 10.—East-west section across Reveille Range at northern boundary of area surveyed.

ECONOMIC GEOLOGY.

The abandoned mining camp of Old Reveille lies 1½ miles north of the area surveyed. The Gila mine, one of the best known of those extensively operated thirty years ago, is situated in Paleozoic limestones and quartzites near the rhyolite contact. The ore occurs in quartz veins and stringers ramifying through brecciated zones in the Paleozoic rocks. The ores on the dump include malachite, azurite, cerussite, and galena, with quartz and gypsum as gangues. Malachite here and there coats the surface of the dump and has doubtless been deposited since the mines were abandoned. Recently considerable work has been done on similar deposits at New Reveille.[a] The rhyolite of the Reveille Range, where examined, has not suffered the alterations which usually accompany ore deposits.

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[a] During the field work, New Reveille was believed by the topographers to be outside the boundary of the area mapped, but more accurate computations have placed it within. In the pressure of reconnaissance work the mines were not examined.

RAILROAD VALLEY

Railroad Valley is a long depression between the Pancake and Reveille ranges on the west and the Grant and Quinn Canyon ranges on the east. Its south end lies in the northeast corner of the area mapped and is of interest because it has two well-developed north-south drainage lines. The playa is 5,106 feet above sea level.

BELTED RANGE.

TOPOGRAPHY AND GEOGRAPHY.

The north end of the mountain range east of Kawich Valley is called by prospectors the Reveille Range, while the south end is known as the Belted Range. The undesirability of using two names for a single mountain range is patent, and as the range immediately north has long been called the Reveille Range the name Belted will here be used for the whole range east of Kawich Valley. Thus defined, the Belted Range extends from the junction of Reveille, Kawich, and Railroad valleys southward 49 miles to Shoshone Mountain, which trends east and west. From the north end of the range the crest courses southward to Wheelbarrow Peak, where it turns to the south-southwest. The range in the latitude of Oak Spring is 13 miles wide. The crest line has an average elevation of 7,000 to 8,000 feet and lies in a median position, except in the central portion of the range, where the long eastward-sloping basalt mesas throw it nearer the western base. Wheelbarrow Peak and a dome 3 miles north of it reach an elevation of 8,600 feet; Belted Peak is 8,340 feet high.

A gentle valley separates the Pogonip limestone from the rhyolite at the north end of the range and a parallel detrital embayment lies west of Cliff Spring. The Pogonip limestone forms hills and ridges elongated parallel to their strike. The Pennsylvanian limestone where metamorphosed by granite forms rugged ridges, but elsewhere its topography is much less accentuated, the ridges being comparatively low and smooth. Minor dip-slope elements are present in all the limestone formations, as well as in the earlier rhyolite near Cliff Spring. The Weber conglomerate forms broad domelike ridges of gentle slope. The earlier rhyolite forms domes and cone-shaped hills with which cliffs are combined near the crest line. Vertical joints are less prominent in the earlier rhyolite of the Belted Range than in that of the Reveille Range, and in consequence spires are uncommon except to the north of Wheelbarrow Peak. The later rhyolite caps prominent buttes, like Oak Spring Butte, whose sides are formed by the soft Siebert lake beds. The basalt mesa country is characterized by level slopes deeply cut by straight-walled canyons.

Remnants of a more mature mountain surface surrounded by recent cliffs and rugged hills occur on Wheelbarrow Peak, on the high peak 3 miles north of it, and in the rhyolite area 5 miles west of south of Wheelbarrow Peak. The old land surface extends 2 miles east of the first-named points. The smooth and gentle slope of this surface is shown on the map, although it is somewhat obscured by the use of 100-foot contours on so small a scale as 1 inch to 4 miles. These mature areas are characterized by few and inconspicuous rock outcrops and a deep soil covered by grass and trees. The contrast between this topography and the sharp ridges and cliffs, practically all a single rock exposure, of the younger topography is very great. Since this old mountain surface developed the Belted Range has been tilted to the east and the older surface has been completely removed from the west versant of the range. (See fig. 11.)

The range north of Belted Peak is bare, but south of this point there is a fair growth of piñon and juniper above 6,500 feet, although the southern quartzite and slate hills are as a rule without timber. A few oak shrubs grow in moist places. The tree yucca and the Spanish bayonet are common on the upper alluvial slopes in the vicinity of Oak Spring. Cliff and Indian springs each flow about 500 gallons of water per day; Wheelbarrow Spring is weak and is probably dry during a part of the summer. Oak, Whiterock, and Captain Jack springs all flow from the Siebert lake beds. Oak and Whiterock springs each flow from 1,500 to 3,000 gallons a day; Captain Jack Spring is considerably smaller.

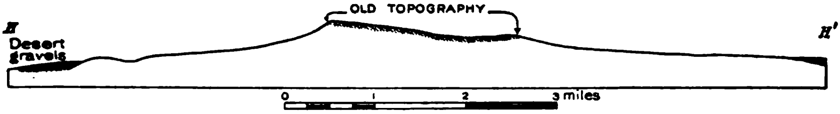

FIG. 11.—East-west profile across Belted Range 3 miles north of Wheelbarrow Peak, showing mature character and present eastward tilt of Pliocene surface.

GENERAL GEOLOGY.

The formations of the Belted Range, from the oldest to the youngest, are as follows: Pogonip limestone, Weber conglomerate, Pennsylvanian limestone, monzonite, post-Jurassic granite, andesite, earlier rhyolite, Siebert lake beds, later rhyolite, and basalt.

SEDIMENTARY ROCKS.

Pogonip limestone.—The Pogonip limestone forms low hogback hills on the western border of the Belted Range from a point 1 mile north of the Kawich-Indian Spring road to the north end of the range. Inclusions of the same rocks occur in the rhyolite and are particularly abundant near its contact with the limestone. A thickness of 4,000 feet of stratified rocks is exposed from a point 2 miles southwest of Belted Peak westward to the detrital deposits mantling the range. The section contains no important stratigraphic break, and while shales and quartzites are interbedded, limestone is the predominant rock. The limestone is typically fine grained, crystalline, and dark gray or black in color. The bedding planes are as a rule massive. Thinner beds of a yellow or brown, more coarsely crystalline limestone are also present, and a single stratum of oolitic limestone was observed. Intraformational conglomerates and cross-bedding, each an indication of shallow-water deposition, occur throughout the section. Nodules and fewer lenses of black chert are present in places. The nodules are in part original, but since the bedding planes in certain instances cut them, they are also in part secondary. A related phenomenon is the silicification of certain beds of limestone to a compact, conchoidally fracturing black jasperoid. The limestones are cut in all directions by veinlets of coarsely crystalline white calcite, and these were evidently formed at several distinct periods, since they cut and, in places, fault one another.

Quartzite forms a prominent bed near the middle of the Pogonip limestone, and in many places shale and quartzite beds are laminated with limestone near the top of the series. The quartzite is usually light in color and fine grained, although some beds are stained red by hematite and others are medium grained. Quartz veinlets with crystal-lined vugs cut the quartzite. Much of the quartzite is argillaceous and grades into slaty shales, which are thin bedded, fine grained, and, as a rule, olive green in color, although locally black or brown. Muscovite films are developed on the parting planes of both the shales and the more argillaceous quartzites.

This sedimentary series was evidently laid down in a sea of moderate depth which at times was shallow. The conditions were on the whole favorable to the deposition of limestone, although at intervals fine fragmental material was carried into that portion of the ancient sea now occupied by the Belted Range. This limestone closely resembles the Pogonip limestone of the Panamint Range, although from its great thickness it may extend well down into the Cambrian. Mr. E. O. Ulrich identified, from material collected by the writer, *Girvanella*-like forms of smaller size and denser structure than those collected from the Cambrian limestone of the Silver Peak Range. He considers these probably of Ordovician age.

Weber conglomerate.—The Weber conglomerate forms the crest and eastern slope of the Belted Range south of Whiterock Spring, as well as broad ridges west of Oak Spring and north of Whiterock Spring. The formation includes a sandstone from 800 to 1,000 feet thick and an overlying shale from 300 to 500 feet thick. While sandstone predominates in one member and shale in the other, some bands of shale are included in the sandstone, as well as sandstone in the shale member.

The reddish or brownish sandstone is either a quartzose rock or an arkose of medium grain. It is somewhat indurated, but when crushed fracture occurs around the grains rather than through them, as in quartzite. The indurated sandstone grades into conglomeratic bands which contain well-rounded pebbles up to 4 inches in diameter. These pebbles are smoky quartz of vein or pegmatitic origin, gray banded flint, pinkish or white quartzite, and black jasperoid seamed with quartz veinlets. The quartzite and jasperoid closely resemble the Cambrian rocks of other portions of the area, and if such is their age, it indicates that between the deposition of the Cambrian and the Carboniferous sediments a period of deformation intervened. The metamorphism of these supposed Cambrian pebbles is such that the beds from which they were derived must have been folded and eroded prior to the deposition of the Carboniferous strata. The arkose grades into thin-bedded shale of olive-green, brown, purple, or light-gray color.

The Weber conglomerate appears to lie conformably beneath the Pennsylvanian limestone, and hence occupies a position similar to that of the Weber conglomerate at Eureka, Nev., as described by Hague.[a] Near Whiterock Spring some peculiar fucoid-like markings occur on a light-gray shale. Mr. E. O. Ulrich states that these resemble *Palæodictyon* and are probably of Carboniferous age.

Pennsylvanian limestone.—Pennsylvanian limestone forms the prominent ridges north of Oak Spring and the low ridges south of the same point. It also covers considerable areas to the east and northeast of Tippipah Spring. Approximately 2,500 feet of this limestone is exposed in the Belted Range, although the top of the formation is not present. It is a fine- to medium-grained gray limestone of dense texture. Certain layers in fineness of grain and density resemble lithographic limestone. Much of it is magnesian, and other portions when struck with the hammer smell oily. Small black flint nodules occur in some beds, and white calcite veinlets are locally abundant. The limestone is for the most part rather heavily bedded, although interbedded shaly layers are fine bedded.

Intraformational conglomerates occur at several horizons, and near the center of the section as exposed is 55 feet of limestone conglomerate. The included pebbles, which reach a maximum diameter of 4 inches, are jasperoid and quartzite, probably of Cambrian age, and limestone, probably from the lower part of the Pennsylvanian section. It seems likely that this conglomerate merely indicates shallow-water conditions and not an important stratigraphic break, since Pennsylvanian fossils occur above and below it. Above this bed numerous thin layers of similar conglomerate and shale are interbedded with the limestone.

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[a] Hague, Arnold, Mon. U. S. Geol. Survey, vol. 20, 1892, pp. 91–92.

The Pennsylvanian limestone appears to overlie the Weber conglomerate conformably. The formation is fossiliferous, and collections were made 4 miles south of Oak Spring and at several horizons northeast of Tippipah Spring. Dr. George H. Girty kindly made the following determinations of Pennsylvanian fossils, the first four lots being found beneath the limestone conglomerate and the fifth above it.

Fossils from Pennsylvanian limestone in Belted Range.

LOT 1.

Fenestella sp.
Rhombopora sp.
Chonetes sp.
Productus cora?
Productus sp.
Aviculipecten? sp.
Phillipsia sp.

LOT 2

Fusulina sp.
Rhombopora sp.
Archæocidras sp.
Derbya? sp.
Marginifera? sp.
Seminula sp.
Aviculipecten sp.

LOT 3.

Chonetes sp. aff. C. permianus.
Seminula sp.
Leda? sp.

LOT 4.

Zaphrentis sp.
Rhombopora sp.
Stenopora sp. cf. S. carbonaria.
Marginifera? sp.
Ambocœlia? sp.
Derbya? sp.

LOT 5.

Rhombopora sp.
Stenopora? n. sp.
Productus sp. cf. P. semireticulatus.
Productus nevadensis?

Siebert lake beds.—Siebert lake beds cover considerable areas north of Oak and Whiterock springs, and a number of small outliers occur on the Carboniferous rocks near by, indicating that the lake beds were at one time continuous with those of Pahute Mesa. Another outcrop lies south of Wheelbarrow Peak, and to the east there are smaller areas not mapped.

A section at Oak Spring is as follows:

Section at Oak Spring.

	Feet.
Later rhyolite	250
Well-bedded, incoherent sandstones and conglomerates; white with some dark gray bands. Many of the layers, which are from 2 to 4 feet thick, show cross-bedding. Crystals of glassy feldspar, quartz, and biotite are abundant in some beds and lacking in others. The pebbles in the conglomerate for the most part are small, but some of them reach 6 inches in diameter	200
Later rhyolite	40
White sediments as above	100
Later rhyolite	60
Salmon pink, white, and yellow sediments as above	280

Chalcedonic quartz, in considerable quantities, is deposited in the cavities of the sediments in this vicinity. The conglomerate near Wheelbarrow Peak incloses many bowlders of earlier rhyolite from 3 to 4 feet in diameter. Such bowlders protect the softer sandstone immediately beneath from erosion, and in consequence they form in places the caps of columns 20 feet high.

These beds appear to be contemporaneous with those of Pahute Mesa and Shoshone Mountain, and like them are considered the equivalent of the Siebert lake beds,[a] of Miocene age, at Tonopah.

IGNEOUS ROCKS.

Monzonite.—Included in the granite near Oak Spring are fragments of a fine-grained, dark-gray, granular igneous rock. On microscopic examination this proves to be a hornblende-biotite monzonite. Titanite and magnetite are accessory minerals.

Granite.—A stock of granite, approximately three-fourths of a mile in diameter, cuts the Pennsylvanian limestone 2½ miles south of Oak Spring and sends many apophyses into it. The granite, forming a dome, set with many exposures in blocklike masses, rises above the near-lying limestone. In the eastern portion of the area it has a sheeting dipping eastward, parallel to the limestone contact. The granite tends to weather into spheroidal masses, although some of the joint blocks have their corners but slightly blunted.

This rock is a light-gray porphyritic granite, characterized by unusually large feldspar and quartz phenocrysts, which lie in a medium- to coarse-grained matrix of white feldspar and biotite. Quartz is an unimportant constituent of the groundmass, the silica having largely separated out in the older crystals. Phenocrysts of pale-pink feldspar, of perfect outline, reaching a maximum length of 4 inches, are the most prominent, in places forming one-third of the rock surface. The feldspar phenocrysts inclose minute blades of biotite zonally arranged. The slightly smoky quartz phenocrysts are perhaps more numerous, though smaller than those of feldspar, their maximum diameter being one-half inch. Phenocrysts of mica 1 inch in diameter are rare. Both feldspar and quartz phenocrysts protrude on weathering and finally drop out. The granite is in places deeply weathered. The smaller feldspars are more kaolinized than the large crystals, while the biotites are bronze-brown in color and are surrounded by hematitic stain which has separated from them. Under the microscope this rock proves to be a biotite-hornblende granite, containing considerable plagioclase and hence leaning toward quartz monzonite. The texture is granular and hypidiomorphic, on account of the presence of plagioclase laths in the groundmass and of the large zonally built orthoclase phenocrysts. The accessory minerals include titanite, zircon, and apatite.

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[a] Spurr, J. E., Prof. Paper U. S. Geol. Survey No. 42, 1905, p. 51.

The granite is cut by dikes of aplite rather poor in biotite. Pegmatite dikes are common. The coarsely granular pegmatite is composed of feldspar and quartz anhedra which reach a maximum diameter of 12 inches. Limonite pseudomorphs after pyrite are inclosed in both quartz and feldspar grains. Graphic granite, with letters one-fourth inch across, is a less common variety of pegmatite. A third facies is an aggregate of coarse feldspar individuals with a few quartz anhedra. Embedded in the feldspar are numerous biotite blades from one-half to 1 inch long. Under the microscope this rock is seen to be composed of large plates of microperthitic orthoclase intergrown with quartz in the manner characteristic of graphic granite. Between these large areas is a granular mosaic of orthoclase and quartz. A few needle-like blades of biotite and grains of magnetite are also present.

Next to the limestone the granite becomes fine grained, although the phenocrysts retain their size and in consequence probably solidified prior to the intrusion of the magma into the limestone. Limonite cubes after original pyrite are particularly common near the contact. The limestone near the contact is metamorphosed to a fine-grained marble of white color, which in some localities contains lenses of pale-gray marble. In less pure layers fibrous tremolite, locally in globular masses, is developed. Other layers are colored greenish yellow by serpentine and chlorite. The more impure layers are changed to grossular garnet, forming a heavy dark-brown rock. This garnet in cavities occurs as beautiful citron-yellow crystals. A heavy rock of deep-green color also proves, on microscopic examination, to be composed of garnet, which even in thin section has a decided green tinge and which is associated with calcite, staurolite, tremolite, quartz, zoisite, titanite, and iron ore. Another thin section of altered limestone proves to be a finely granular marble, between the calcite grains of which are tremolite and colorless garnet grains and a few irregular areas of chlorite. Still another thin section is composed of large plates of calcite and quartz, in which chlorite, tremolite, and colorless garnet are micropoikilitically inclosed. The shale of the Weber conglomerate is metamorphosed to a slaty shale, in which nests of tiny muscovite tablets are developed. Other facies contain numerous pyrite crystals. The most interesting metamorphosed shale is a black argillite, in which are many rectangular white columns with black cores. Under the microscope these columns embedded in the carbonaceous argillite are seen to be chiastolite, a variety of andalusite. On its edges this mineral is somewhat altered to muscovite.

This coarse granite porphyry, characterized by two generations of mineral solidification and associated with aplitic and pegmatitic facies, clearly bridges the interval between granite and granite porphyry. The granite cuts Pennsylvanian limestone and is doubtless one of the post-Jurassic series. It rather strikingly resembles the granite outcropping 5 miles north of Ammonia Tanks.

Several smaller masses of similar granite occur near the main stock. The mass 1½ miles east of south of Oak Spring lacks phenocrysts, and, since it is only 200 yards in diameter, is very similar in other respects to the contact facies of the main mass. It is medium grained or in a few places medium coarse grained. The granite is more altered than that of the main mass, and the mica is usually muscovite, apparently secondary to biotite. The granite grades into a coarse pegmatite, which in turn grades into pegmatitic quartz, each of which contains pyrite altered to limonite. The larger of the limonite cubes are one-half inch in diameter, and the pyrite was undoubtedly an original constituent of the pegmatite. The pegmatite has some miarolitic cavities into which quartz and feldspar crystals 1 inch long project. A third mass of granite lies between the two already described, and two small outcrops isolated in the alluvial deposits appear to have been separated from the largest mass by erosion.

Andesite.—About 2½ miles west of Wheelbarrow Peak is an exposure of andesite partially covered by the earlier rhyolite flows. The rock has a dense reddish-black groundmass, in which are embedded many medium-sized striated feldspar phenocrysts, which are either glassy and colorless or cloudy and white. Hand specimens suggest the presence of hornblende. Under the microscope the groundmass appears as a glass containing many tiny laths of plagioclase. The phenocrysts are plagioclase (labradorite), brown hornblende, with a reaction rim of magnetite, which in some instances completely replaces the hornblende, and a little augite. The plagioclase phenocrysts, some of which are complex crystals, are somewhat rounded by magmatic corrosion and, as a rule, show beautiful zonal growth. Inclusions of a greenish-gray andesite, rather similar, altho with smaller feldspar phenocrysts, occur in rhyolite near Cliff Spring. In the gravels of the valley 1½ miles west of Wheelbarrow Peak are bowlders of a greenish-gray andesite. Phenocrysts of altered greenish-white feldspar are abundant, and associated with these are biotite and either hornblende or pyroxene phenocrysts. The source of this andesite is unknown. It strikingly resembles the post-rhyolitic andesite of the Kawich Range and may perhaps be younger than the earlier rhyolite of the Belted Range. Certainly in this range andesite older than the rhyolites occurs, while andesitic eruptions may also have followed the rhyolitic effusion.

Earlier rhyolite.—The earlier rhyolite is the predominant rock of the northern part of Belted Range, and from its rather striking bands of red, purple, gray, and brown, the name of the range is derived. Of the many rhyolitic facies perhaps the most common has a rather dense reddish groundmass, in which are embedded medium-sized phenocrysts which equal or exceed it in bulk. The description of the phenocrysts of the earlier rhyolite of the Kawich Range applies almost equally well to those of this formation. Biotite, however, is the predominant phenocryst in a facies outcropping 1½ miles northwest of Cliff Spring. Hornblende phenocrysts are very rare. The rhyolite varies in color from white, gray, brown, or purple to black. In texture the groundmass varies from glassy with well-developed flow lines, perlitic cracks, and spherulites through pumiceous to lithoidal. The rhyolites in the vicinity of Wheelbarrow Peak are more glassy and appear to be poorer in phenocrysts, particularly quartz. Chalcedony is abundart on joint planes, and throughout the area surveyed an unusually great development of this form of secondary quartz is associated with the more glassy facies. The only thin section examined proved to be a normal rhyolite with partially devitrified brown glassy groundmass.

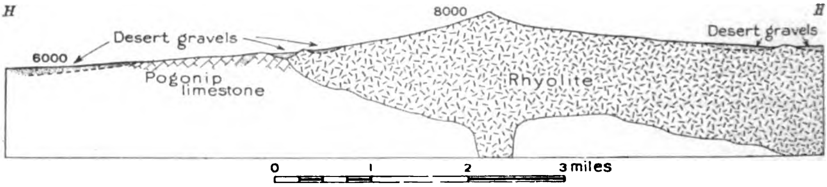

FIG. 12.—East-west section across Belted Range through Belted Peak.

Near Cliff Spring the red rhyolite of the cliffs has been bleached to a yellowish white by surface waters along joints and irregular cracks. The contact between the bleached and unbleached portions is unusually sharp. The joints are often offset regularly, and the bleaching follows such offsets. Microscopic examination shows that the bleaching is due to the removal of the hematite coloring matter of the somewhat devitrified glass. It is probable, in consequence, that considerable portions of the white chalky rhyolite of the range have been produced by similar bleaching.

Columnar jointing, due to contraction during cooling of the lava, is particularly well developed on a hill isolated in the wash, 1½ miles west of Cliff Spring, to the north of the road. The columns are from 6 to 12 inches in diameter and vary in position from vertical to horizontal, intermediate directions being common.

The rhyolite as seen on either flank of the range is clearly a flow, which in places is over 2,000 feet thick. Belted Peak has some of the characteristics of a vent (fig. 12), although the rhyolite may have been extruded from a long fissure near and parallel to the crest line, a suggestion which, however, requires for proof more careful field observation than was possible in the present reconnaissance. The relations between the small rhyolite mass 2 miles south of west of Belted Peak and the Paleozoic rocks are poorly exposed, but the rhyolite probably represents the lower portion of the rhyolite flow rather than a dike, since no dikes were observed in sedimentary rocks to the west.

The earlier rhyolite is similar lithologically to that of the Kawich and Reveille ranges, and like them lies beneath the Siebert lake beds. All three are practically of the same age, probably early Miocene.

Later rhyolite.—Later rhyolite caps Oak Spring Butte (see fig. 13) and forms a lower bench on the same butte and a similar bench on the ridge north of Whiterock Spring. It also covers large areas to the west, on Pahute Mesa. The predominant facies is a resinous or glassy rhyolite composed of light-gray and black flow bands and lenses. Perlitic parting is locally present. Medium-sized phenocrysts equal the groundmass in bulk and in the hand specimen consist of unstriated feldspar, often showing beautiful color plays, and colorless quartz in rounded grains or dihexagonal pyramid and prism crystals. The microscope shows the presence also of smaller phenocrysts of deep-green augite and biotite. Another facies is a reddish-gray aphanitic rock with a few phenocrysts of feldspar and black mica. Some quartz and plagioclase phenocrysts are also visible under the microscope in the devitrified-glass groundmass.

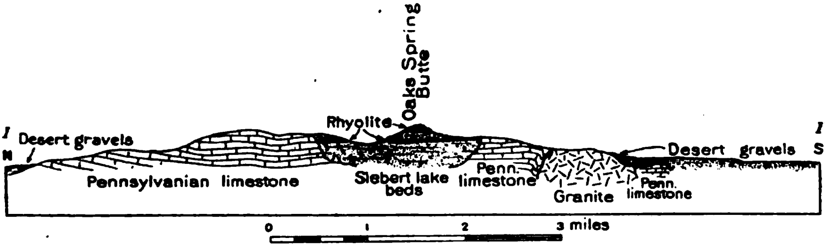

FIG. 13.—North-south section through Oak Spring Butte, Belted Range.

The later rhyolite is a flow, in part contemporaneous with the Siebert lake beds, but mostly younger. It is therefore of middle and possibly late Miocene age. It is contemporaneous with the rhyolite of Shoshone Mountain and Pahute Mesa, and probably with the later rhyolite of the Kawich Range and of Stonewall Mountain and with the later rhyolite and biotite latite of the Amargosa Range.

Basalt.—Basalt covers considerable areas near the middle of the Belted Range. The low hills at the north end of the range also appear from a distance to be basalt. The basalt, where examined, is lithologically similar to and probably contemporaneous with that of the Reveille Range, and, like it, overlies the eroded earlier rhyolite. It is probably of late Pliocene age. The surface of the Belted Range was, however, probably less rugged than that of the Reveille Range at the time of the basalt effusion.

STRUCTURE.

The Pogonip limestone, as exposed in the Belted Range, lies in a monocline which strikes north and dips 20° to 30° W. next Kawich Valley and 70° W. southwest of Belted Peak. Superimposed upon the main fold are a few minor isoclinal folds of similar strike, as well as gentle cross folds. This is probably the eastern limb of a broad syncline which underlies Kawich Valley and which has for its western limb the eastward-dipping monocline of Quartzite Mountain. A number of dip faults of east-west strike cut the Pogonip limestone, with a uniform offset of the beds on the north side of the faults to the east. The lateral displacement of the largest faults shown on the map is 100 feet.

The Carboniferous rocks are bent into rather open folds, which near Oak Spring have north-south axes and to the north of Tippipah Spring, as a rule, course northeast and southwest. Small isoclinal folds passing into overthrust faults occur, particularly in the shale. The intrusion of the granite considerably disturbed the strata on its north side, while the beds on the other sides were but little affected. The folding was evidently in part prior to the granite intrusion, in part due to it, and in part later, since the granite in places has a sheeting parallel to the bedding planes of the limestone. Since the folding of the strata some normal faults have been formed.

Prior to the extrusion of the earlier rhyolite in the northern part of the range the Pogonip limestone formed a mountain range possibly somewhat lower than the present Belted Range, with its crest 3 miles west of the present crest line. In the southern part of the range prior to the deposition of the Siebert lake beds the Carboniferous rocks had at least a gently accentuated surface, since numerous hillocks of the older rocks protrude through the younger sediments north of Tippipah Spring. The Siebert lake beds at Oak Spring have been uplifted without important flexure. After this uplift erosion developed a mature mountain surface, which prior to the extrusion of the basalt was tilted to the east. The basalt flows on the east side of the range dip to the east at the rate of 500 feet to the mile, possibly indicating that the eastward tilting continued after the outflow of the basic lava.

ECONOMIC GEOLOGY.

OAK SPRING.

At Oak Spring a number of prospects are being developed. In granite 1½ miles nearly due south of Oak Spring quartz veins of pegmatitic origin, from 1 to 3 feet wide, striking N. 30° E. and dipping 15° NW., have been staked. The quartz is white and slightly sugary and contains vugs with small quartz crystals. Some of it is intensely brecciated, the cracks being stained by hematite and limonite. Sulphides are sparingly present and consist of pyrite, chalcopyrite, galena, and zinc blende, named in the order of their abundance. From these hematite, limonite, malachite, azurite, and cerussite are derived as secondary minerals. A coating of an unctuous mineral in silvery tablets frosts some of the cavities. The values in this locality are said to be gold with less silver. The deposits are genetically similar to the mineralized pegmatite veins of Lime Point, in Slate Ridge, and the sulphides were probably introduced into the pegmatitic quartz after its solidification.

The pegmatitic quartz veins abundant in a small granite mass three-fourths of a mile east of south of Oak Spring contain pyrite crystals, as do the less acidic pegmatites and the surrounding and genetically related granite. The quartz is said to carry good gold and silver values, presumably in the pyrite.

About 300 yards southwest of Oak Spring and down the same ridge is a 25-foot shaft in Pennsylvanian limestone, here locally horizontal. A vein 2 feet wide, which strikes N. 35° E. and dips 70° NW., cuts the limestone. The vein is formed of malachite, chrysocolla, and a jaspery quartz, which is deeply stained by blotches of manganese dioxide and limestone. Striking vugs in malachite lined with later azurite which in turn is covered with clear quartz crystals resemble copper-sulphate crystals. Massive yellowish-gray cerussite (lead carbonate) is also present. A yellowish-green, finely scaly coating on fractures was determined by Mr. Waldemar T. Schaller to be either emmonsite or durdenite, hydrated ferric tellurites. The presence of the compound of tellurium is of considerable interest, since it indicates the presence of a telluride among the original minerals of the post-Jurassic ore deposits. Emmonsite is one of the last secondary minerals to form and coats both jaspery quartz and chrysocolla. Postmineral faulting has occurred. The secondary minerals, which alone are seen, partly replace the limestone and partly fill preexisting cavities.

The so-called turquoise mine at Oak Spring is a small cut in the metamorphic Pennsylvanian limestone 1½ miles south of the spring and three-fourths of a mile from the granite contact. Two veins strike north and south and dip 65° W., apparently parallel to the bedding of the limestone, which is here partially marmorized and silicified. The wider vein varies in width from 2 inches to 1 foot and can be traced several hundred feet. Four feet away is a parallel vein, the two being connected by a few chrysocolla stringers. The veins are composed of a mottled mosaic of chrysocolla and a dark compact jaspery quartz, stained in some places by limonite and in others by manganese dioxide. The chrysocolla is usually verdigris green, although picked pieces are a beautiful robin's-egg blue. The substance is usually opaque, but some is slightly translucent. The chrysocolla is commonly massive, locally with a botryoidal structure, and in some massive phases an occasional cleavage face is seen. It is cut by veinlets of manganese dioxide and white calcite or quartz. Chrysocolla veinlets of slightly different color cut one another, showing that the formation of this mineral extended over a considerable period. Associated with it is a crystalline, bottle-green, semitransparent mineral whose cleavage faces reach a length of one-half inch. A radial structure is observed in places. This mineral is embedded in the chrysocolla or cuts it in veins and is of practically contemporaneous age. It is probably brochantite, a hydrous sulphate of copper. Both the chrysocolla and the brochantite were determined by Mr. Waldemar T. Schaller. Postmineral faults cut the veins and parallel them. Pieces of blue chrysocolla closely resemble turquoise, and several hundred pounds of the material have been sold for this gem. The mineral takes an excellent polish. The largest piece of pure chrysocolla seen was 6 by 3 by 2 inches.

In these copper deposits the minerals exposed are all secondary. Malachite, chrysocolla, brochantite, cerussite, a jaspery quartz, and limonite seem practically contemporaneous. There is considerable evidence that the formation of the copper minerals and the jaspery quartz extended over a considerable period, during which some fracturing occurred and in consequence the relations between these minerals are complex. They partly replace the limestone and partly fill fissures. Azurite, emmonsite, quartz, and calcite are of later origin.

Narrow seams and veins of quartz are rather widely distributed in the Pennsylvanian rocks, particularly near granite intrusions. In the slaty shales and quartzites throughout the southern portion of the range such veins occur. A quartz vein 2 inches thick which carries some pyrite cuts the shale one-half mile south of Whiterock Spring. Specimens of quartzite, which evidently came from the quartzite to the north, were found at Tippipah Spring. These were rather strongly stained by malachite and hematite.

Oak Spring furnishes sufficient good water for domestic purposes, and there are several other springs in the general vicinity. Oak Spring Butte is timbered to some extent. Calientes, on the San Pedro, Los Angeles and Salt Lake Railroad, is the natural shipping point.

OTHER AREAS.

Prospects are located on either side of the road from Kawich to Cliff Spring, near the eastern border of the Pogonip limestone. The supposed ore is in part a fine-grained quartzite and in part vein quartz, in which are small disseminated iron-pyrite cubes and thin stringers of pyrite. The veins where examined are thin.

Reefs of silicified rhyolite similar to that of the Kawich Range occur south of Belted Peak. The alteration of the rhyolite is strikingly like that at Silverbow, Eden, and other mining camps situated in rhyolite, and the ground is worthy of prospecting. Over a considerable area east and southeast of Belted Peak, near the boundary of the area mapped, the rhyolite appears in a distant view from its color and topography to be much altered.

PAHUTE MESA.

TOPOGRAPHY AND GEOGRAPHY.

The name Pahute Mesa is applied to the lava-capped table-land stretching from Stonewall Mountain on the northwest to the Belted Range on the southeast, a distance of 48 miles. The mesa is 12 miles wide except near its center, where Tolicha Peak cuts it into two portions. Notwithstanding this break these divisions are so similar, both topographically and geologically, that it is convenient to describe them under a single name.

Pahute Mesa consists of a series of benches one above another, the surfaces of which are determined by resistant flows of lava (Pl. II, *A*). These level benches are trenched deeply by canyons, while hills of older rocks and cones, the vents of the lavas, rise from their surfaces. Southeast of Stonewall Mountain the mesa has an average elevation of 5,500 feet. It gains in altitude to the southeast and near the Belted Range the highest mesa bench is 7,500 feet high. The southward-facing scarp is 1,500 feet high.

The western portion of the mesa is without vegetation other than sage and related shrubbery and the yucca. The higher portions of the eastern edge are, on the other hand, covered with a fairly heavy growth of piñon and juniper, and grass grows luxuriantly in the higher valleys, making this portion of Pahute Mesa the best winter range in the area mapped. The mesa has no large springs, Pillar Spring containing less than 50 gallons of water. A well sunk in a canyon 3 miles north of east of Gold Center yields about 300 gallons of water a day. It is 90 feet deep and passes through Recent gravels into tuffaceous sediments beneath the basalt. Tanks are common on the surface of the mesa, but in summer, with one probable exception, these are dry. A little bad water can be procured, probably throughout the year, by digging in the gravels at Ammonia Tanks. On account of the lack of water Pahute Mesa is more dangerous in summer than Death Valley.

GENERAL GEOLOGY.

On account of its inaccessibility and the comparative simplicity of its geology, but little time was devoted to the mapping of this region. While many inaccuracies exist in the geologic boundaries as here laid down, they broadly represent the main features. The latest rhyolite and later tuffs beneath the basalt in the northwestern portion of the mesa are not differentiated from the basalt, while the separation of the Siebert lake beds and the middle rhyolite near the Belted Range is only approximate.

The list of the formations of Pahute Mesa, from the oldest to the youngest, is as follows: Mica schist, pre-granite monzonite, post-Jurassic granite, earliest rhyolite, biotite andesite, Siebert lake beds, middle rhyolite, latest rhyolite, later tuffs, and basalt.

METAMORPHIC ROCKS.

Mica schists.—At Trappmans Camp the granite contains fragments of mica schist, and an outcrop several hundred yards in diameter, 1 mile east of Trappmans Camp, may extend eastward a considerable distance beneath the Tertiary lavas. These rocks are crenulated and foliated schists. One facies is a dark-brown schist apparently composed of tiny plates of biotite and muscovite well arranged in the plane of foliation. The microscope shows that the two micas are distributed in rather distinct bands parallel to one another. Andalusite, sillimanite, and finely divided magnetite are present as accessories. Another facies is a silvery schist composed of muscovite, with here and there an ellipsoidal aggregate of deep-green chlorite. Under the microscope this proves to be a schist composed of the essential constituents, muscovite, chlorite, and quartz, and the accessory constituents, sillimanite, zircon, andalusite, and rutile. Nothing is known concerning the age of these intensely metamorphosed rocks beyond the fact that they are much older than a granite of supposed post-Jurassic age. They are perhaps of Cambrian age, since they somewhat resemble the more metamorphosed Cambrian schists near granite at Gold Mountain.

SEDIMENTARY ROCKS.

Paleozoic quartzite.—Prospectors report that quartzite occurs on the north slope of Mount Helen, but the locality was not visited by the writer.

Siebert lake beds.—The Siebert lake beds west of the Belted Range are similar to those described in the vicinity of Oak Spring. (See p. 122.) The beds are either horizontal or tilted up to angles of 30°. Probably to be correlated with these are the white conglomeratic sandstone 10 miles north of Tolicha Peak, and green tuffaceous sediments 7 miles southwest of Trappmans Camp. From the tuffaceous beds, which contain quartz, feldspar, and biotite crystals, Mr. B. D. Stewart collected pieces of silicified wood which Dr. F. H. Knowlton states belonged to a deciduous tree not older than the Tertiary.

Later tuffs.—Beneath the basalt of Pahute Mesa east of Stonewall Mountain are tuffs and rhyolite flows which appear to be similar to the later rhyolite and later tuffs of the Goldfield hills. (See pp. 72, 74.) Similar beds outcrop at many points where erosion has removed the basalt, and it is probable that these beds underlie the greater portion of the basalt. No attempt has been made to separate them from basalt on the map. A section east of Stonewall Mountain is as follows:

Section east of Stonewall Mountain.

	Feet.
Basalt.	
Rhyolite	5
Gray tuff with small pebbles	15
Rhyolite	7
Yellow tuff, very rich in pebbles of pumice, which reach a maximum diameter of 1 inch	20
Gray, rather incoherent, conglomeratic tuffaceous sediments. The pebbles, which reach a maximum diameter of 6 inches and become smaller toward the top, are formed of rhyolitic pumice, a quartz-poor rhyolite like the later rhyolite of Goldfield, and basalt. Tiny crystals of feldspar, similar to the phenocrysts of the rhyolite of Goldfield, are present	55
Yellow tuffs, like above	10

From this section and that at Goldfield it may be inferred that a lake covered considerable territory in the northern part of the area under discussion, probably in late Pliocene time. The deposits of this lake are separated from those of the Pahute Lake (Siebert lake beds) by an erosional unconformity, and are probably older than the playa deposits of the older alluvium in Stonewall Flat. Between the Pliocene lake beds and the older playa deposits there is little relation, although the deposits laid down in playas probably represent the last stages of the drying up of the lake in which the lake beds were formed. Spurr[a] found deposits of a late Pliocene lake widely distributed in Nevada, and it is possible that this lake and the one here described are broadly contemporaneous.

Recent desert gravels.—Recent desert gravels mask the bed rock over a considerable area east of Fortymile Canyon and extend some distance up the main canyons.

IGNEOUS ROCKS.

The igneous rocks of Pahute Mesa include pre-Tertiary granular rocks and Tertiary dikes and lava flows.

Pre-granite monzonite.—In the granite 5 miles north of west of Whiterock Spring are inclusions of a gray fine-grained granular rock. Both striated and unstriated feldspars are present with quartz and biotite, and the rock is similar to the monzonite included in the post-Jurassic granitoid rocks of Gold Mountain and the Belted and Panamint ranges.

Post-Jurassic granite.—Granite forms the hills at Trappmans Camp and also outcrops 5 miles north of west of Whiterock Spring. The rock at Trappmans Camp is a light-gray fine- to medium-grained biotite-muscovite granite. It forms low, rounded hills and shallow valleys, and outcrops are inconspicuous. The granite is cut by several systems of intersecting joints and by faults and zones of brecciation. In consequence the residual masses are squared blocks, more or less rounded. Under the microscope the granite shows as an allotriomorphic, granular rock, composed of orthoclase, quartz, plagioclase, biotite, muscovite, and zircon. The muscovite is in part original and in part an alteration product of feldspar. The rock has been considerably mashed, and quartz and muscovite have been deposited in the fractures of feldspar and quartz.

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[a] Spurr, J. E., Bull U. S. Geol. Survey No. 208, 1903, pp. 124–125, 209–210, etc.

The granite grades into and is cut by irregular masses and dikes of pegmatite, composed of feldspar and quartz anhedra up to 1 inch in diameter. Quartz stringers and veins of pegmatitic origin, some of which are several hundred feet long and 40 feet wide, are common. The quartz on portions of the borders of the larger masses contains fragments of granite and sends well-defined veins into the granite. At other places single individuals of quartz on the contact seem common to both pegmatitic quartz and granite, and arms of feldspar extend from the granite into the quartz. Evidently the quartz solidified contemporaneously with some portions of the granite and subsequently to other portions. A few thin dikes of fine-grained aplite, which stand in relief on weathering, cut the granite.

A granite mass 1 mile long occurs in the midst of the Siebert lake beds 5 miles north of west of Whiterock Spring. It is low and covered by a yellowish granite soil from which protrude low, rounded granite domes. Near its center is a rugged hill, set with sharp pinnacles, whose forms are controlled by the well-developed joints. The granite is coarse grained and is composed of pink feldspar, white semitransparent quartz, and biotite. Feldspar and quartz reach a maximum length of three-fourths of an inch. Under the microscope the granite shows as a hypidiomorphic granular rock formed predominantly of large orthoclase plates poikilitically inclosing quartz anhedra and plagioclase laths. A little biotite is also present, and this, since it occurs along fractures in orthoclase, has been considerably recrystallized. The accessory minerals are titanite, apatite, and magnetite, the last probably titaniferous, since it is surrounded by secondary titanite.

The granite is cut by narrow dikes of pink aplite, practically lacking biotite. These dikes weather in relief. In the granite are ellipsoidal masses of quartz-feldspar pegmatite from 4 inches to 5 feet in diameter, the contact between the granite and pegmatite being in some instances sharp, in others gradational. Feldspar and quartz individuals with a maximum diameter of 6 inches, together with a few biotite plates, compose the pegmatite. This rock grades into pegmatitic quartz. The ellipsoidal form and the absence of channels from one mass to another in the place of observation suggest that the pegmatite formed in place from the local residual fluids of the granitic magma.

The granite of Trappmans Camp contains inclusions of the schist already described and of a black Paleozoic quartzite. It is cut by dikes of the earlier rhyolite, and the later tuffs overlap it. It resembles the granite of Lone Mountain. The granite near Whiterock Spring is much older than the Siebert lake beds and closely resembles that near Oak Spring in the Belted Range. Each granite is probably of post-Jurassic and pre-Tertiary age.

Earliest rhyolite.—The earliest rhyolite protrudes from the basalt in a number of hills in the northwestern portion of the mesa. It evidently occurs for the most part as a flow, although dikes of rhyolite cut granite at Trappmans Camp. These dikes reach an observed maximum width of 40 feet. They are formed of a lithoidal, brownish-gray rhyolite with conchoidal fracture. The feldspar, quartz, and biotite phenocrysts rarely exceed a length of one-tenth of an inch and are exceeded in bulk by the groundmass. The flow at Wilsons Camp is composed of a white phenocryst-rich rhyolite, in which biotite is present in some places and absent in others. The rock of the inlier, 9½ miles northwest of Tolicha Peak, is a semipumiceous, brownish-gray rhyolitic glass, with a few small phenocrysts. Pebbles of black obsidian occur on the mesa near by. Other hills in the vicinity were not visited, but on the basis of their color and the report of prospectors some are mapped as rhyolite. Beyond the fact that the rhyolite of this vicinity is younger than the granite and older than the basalt, its age is unknown. It is believed, however, that the different masses are portions of the rhyolite of the Cactus Range buried by later lava flows, and are in consequence of early Miocene age.

Biotite andesite.—Biotite andesite forms the inlier of Gold Crater and several smaller inliers near by, and also occurs as dikes cutting the rhyolite at Wilsons Camp and the granite at Trappmans Camp.

The biotite andesite at Gold Crater forms a group of low hills which protrude above the basalt, later rhyolite, and later tuffs. It is evident that the andesite flow was eroded into hills prior to the formation of the younger rocks, and it is probable that the younger rocks never completely covered the summits of these hills, although liquid lava dammed up against their sides. The biotite andesite here is for the most part intensely altered, but appears to have been originally a dense gray rock with phenocrysts equaling the groundmass in bulk. The phenocrysts are medium sized and consist of predominant feldspar in laths, biotite, and locally hornblende. Flow banding and flow breccias are present. Under the microscope the microfelsitic groundmass is rather ill defined, but seems to be composed predominantly of plagioclase and orthoclase. The phenocrysts include sericitized feldspars, which were at least mainly plagioclase, biotites altered to muscovite and magnetite, and some hornblende-like forms of serpentine and limonite.

The biotite andesite at Wilsons Camp is a highly altered, finely granular rock of pale-greenish color, containing many phenocrysts of white altered feldspar and some of bronze biotite. Probably to be correlated with this rock is a much altered greenish-gray, finely granular rock which occurs in dikes at Trappmans Camp. Laths of altered feldspar, columns of hornblende, and tiny tablets of biotite are determinable in the hand specimen. The microscope shows that the much altered groundmass was probably originally a glass with a few plagioclase laths (hyalopilitic). The only phenocrysts recognizable are large calcitized plagioclase and chloritized biotite and a few small, fresh orthoclase tablets. Aggregates of secondary minerals suggest the presence of hornblende or pyroxene. Apatite and magnetite, probably titaniferous, are accessory minerals.

The andesite at Wilsons Camp bears the same relation to the rhyolite as the biotite andesite of the Cactus Range, and the two are doubtless contemporaneous and of middle Miocene age. The andesite of Gold Crater is much older than the latest rhyolite. Lithologically it is not very different from the biotite andesite and is provisionally correlated with it. It is, however, possible that it is the flow equivalent of the monzonite porphyry of the Kawich Range.

Middle rhyolite.—The middle rhyolite, evidently a flow, is the predominant formation of Pahute Mesa east of Thirsty Canyon. The most widely distributed type is a gray or pink lithoidal rhyolite, in which the groundmass is exceeded in bulk by the medium-sized phenocrysts. The latter include glassy orthoclase, colorless or slightly smoky quartz, and, usually, biotite. This variety in many places contains small fragments of a white pumiceous rhyolite and in consequence is a flow breccia. Other facies include dense rocks of red, brownish, or gray color, with few phenocrysts. Flow banding, spherulites, and perlitic parting accompany the denser groundmass in much of the rock. Black glasses with feldspar phenocrysts occur near Ammonia Tanks, and gray semipumiceous glasses with abundant feldspar and quartz phenocrysts are found on the east side of Silent Canyon, 4 miles south of its mouth. This rhyolite for the most part lies upon the Siebert lake beds and it is to be correlated with the later rhyolite of the Belted Range. It is presumably of late Miocene or early Pliocene age.

Latest rhyolite.—The latest rhyolite occurs below the basalt in the vicinity of Stonewall Mountain and probably outcrops in many other places on the border of the mesa that are shown on the map as basalt. It is interbedded with and overlies the later tuffs. A section already described (see p. 133) shows that there are two thin flows of this rhyolite. The lower flow is a dense grayish-purple rock containing a vast number of small phenocrysts. Under the microscope the groundmass is seen to be a glass with highly developed flow lines. The phenocrysts all appear to be orthoclase. The upper rhyolite is similar to the lower, although it contains slightly larger orthoclase phenocrysts, and in addition a few tiny biotite and quartz phenocrysts are visible. The younger rhyolite of Pahute Mesa and that of Goldfield hills are similar lithologic units occupying like stratigraphic positions, and without doubt are contemporaneous and probably of late Pliocene age.

Basalt.—Flows of basalt cover Pahute Mesa northwest of Tolicha Peak, similar flows extend eastward from Quartz Mountain to Thirsty Canyon, and a third area of considerable size lies west of Timber Mountain. The last-named mass appears from a distance to have flowed from two cones, one 5 miles northeast and the other 8 miles southeast of Timber Mountain. Black Mountain, from a distance, also resembles a volcanic cone, and the north peak of Mount Helen may have been an ancient vent.

The basalt of Pahute Mesa includes vesicular and nonvesicular facies, the former red, the latter black. In some of the basalt white striated feldspars, reddish altered olivines, and black pyroxenes are prominent, while in other portions these phenocrysts are inconspicuous. Stratigraphically the basalts of Pahute Mesa and of the Goldfield hills have identical positions and they are considered of late Pliocene age.

STRUCTURE.

Pahute Mesa northwest of Tolicha Peak is capped by lava flows, which dip gently in all directions from a center 5 miles southwest of Mount Helen. The only structural feature of interest in this portion of the mesa is the slight rise of the lava sheets as they approach the older hill groups, well seen at Gold Crater and on the southeastern face of Stonewall Mountain. A similar gentle dome is present in the mesa between Quartz Mountain and Thirsty Canyon, but eastward from the canyon the mesa gradually rises, owing probably to comparatively recent uplifts of the Kawich and Belted ranges. In this portion of the mesa normal faults with north-south strike, few of which have a displacement of over 50 feet, are common. Although of late Tertiary age, these faults do not exhibit fault scarps, since erosion has planed down the upthrown side. In some instances, however, the downthrown side, being more resistant, is now a scarp.

ECONOMIC GEOLOGY.

Three mining camps are situated in Pahute Mesa—Trappmans Camp, Wilsons Camp, and Gold Crater.

TRAPPMANS CAMP.

Trappmans Camp lies 34 miles south of east of Goldfield. The veins were discovered by Hermann Trappman and John Gabbard in June, 1904, and at the time of the writer's visit a year later five men were opening up the veins, the chief development being a shaft 50 feet deep.

The prospects are in granite, and three distinct periods of vein formation were noted—first, quartz lenses probably of pegmatitic origin; second, quartz veins of distinctly later formation, which in one place are said to cut a rhyolite dike; and, third, quartz veins of a third generation which cut the second. (See fig. 14.) The latest veins are in places well crustified.

The pegmatitic quartz forms bodies varying from minute stringers in the granite to lenses one-fourth mile long and 40 feet wide. The quartz is hard and whitish, and in some places it is intensely brecciated and stained by limonite. It is said to carry silver and gold values.

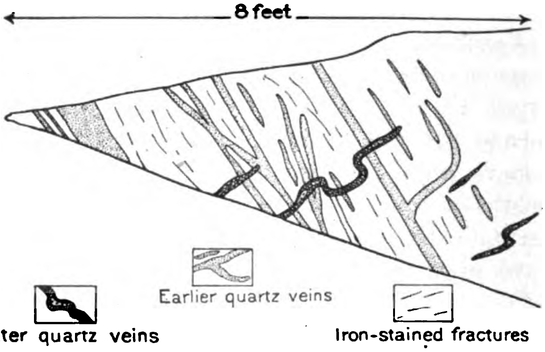

FIG. 14.—Second and third systems of quartz veins in granite at Trappmans Camp, as exposed on face of incline.

The quartz veins of the second class have sharp contacts with the granite. These veins are exceedingly common in the vicinity of Trappmans Camp and vary widely in strike and dip. In limited areas they tend to form series of veins along parallel joint planes in the granite. In width the veins vary from an inch or less to a foot or more, and some of the parallel series are a number of feet thick. Locally these veins are faulted, as indicated by the presence of breccias, while the surrounding granite shows considerable differential movement. The quartz is slightly bluish, but is usually heavily stained red or brown by hematite and limonite. Vugs elongated parallel to the direction of the veins are sometimes seen. On encountering the pegmatitic lenses, in the one instance noted, these veins are deflected downward.

The veins of the third class are of later origin than those of the second, which they cut. As a rule they are more narrow and less continuous and dip more steeply than the veins of the second class. In places they curve sharply. The quartz in them is similar to that in the second group.

In the vicinity of the vein the granite is cut by partings stained by limonite and manganese dioxide, which are parallel to or join the quartz veins at low angles, and the surrounding kaolinized granite is said to carry values. The granite near the veins is in places thickly peppered with cubes of pyrite altered to limonite.

The ore of the two younger sets of veins so far encountered is practically all oxidized, although a little original galena remains. The predominant original sulphide was pyrite, and limonite cubes after pyrite are common in the quartz. Assays show the values to be in the proportion of one of gold to four of silver. Some silver chloride was noted, while secondary native silver is reported. In one prospect calcite is associated as a gangue with quartz.

While the quartz of the first set of veins is of pegmatitic origin, its mineralization is probably later and genetically connected with the filling of the fissures of the second set, probably in Tertiary time. After the veins of the second system were fractured another period of mineralization followed, perhaps in late Tertiary time. Later the veins were crushed and surface waters have more or less completely oxidized the sulphides.

Wood and water are hauled from Antelope Springs, about 9 miles away. Trappmans Camp is 40 miles by road from Goldfield.

WILSONS CAMP.

Wilsons Camp is 2 miles north of Trappmans Camp and was discovered in May, 1904. Five miners were employed in July, 1905, and at that time several shallow shafts and short tunnels were open. The country rocks, white altered rhyolite and biotite andesite, are cut by rather steeply dipping quartz veins, the majority of which strike northeast, although some strike east. The quartz veins, many of which are crustified, are characterized by quartz-lined vugs. Since its formation the quartz has in some instances been crushed. Limonite and less commonly malachite stain the quartz. The reported assay values run from $110 to $180 per ton and average one of gold to five or six of silver. These quartz veins are to be correlated with the veins of Silverbow. The economic conditions at Wilsons Camp are similar to those at Trappmans.

GOLD CRATER.

The mining camp of Gold Crater is situated 10 miles east of the summit of Stonewall Mountain. The first locations were made in

May, 1904. In the fall of 1904 several hundred people rushed to the camp, but few remained long. At the time of the writer's visit (July 7, 1905) a number of lessees were at work. The country rock, silicified and kaolinized biotite andesite, has been fractured and in many places faulted and brecciated. The intensely silicified andesite is a white or gray rock with conchoidal fracture. In some instances it is porous through the removal of the phenocrysts and in others the casts have been filled by milky quartz. The iron-stained outcrops are very rugged, since silicification and consequently the resistance of the rock to erosion are very irregular throughout the mass. Under the microscope this silicified facies is seen to be a medium to very fine mosaic of quartz and some chalcedony, with here and there a blotch of limonite. No phenocrysts remain, although a few sagenitic webs of rutile suggest the former presence of biotite. By kaolinization the rock is reduced to a chalky mass, in which biotite phenocrysts, altered to a silvery mica, alone are visible. It is intensely stained by limonite and hematite, especially along fractures, and from such places rich gold pannings are obtained. A little chrysocolla was observed along some joints, while a thin coating of hyalite has been deposited since the oxidation of the sulphides. The ore is said to run from $40 to $240 in gold per ton.

Waters carrying silica and metallic salts in solution appear to have ascended along faults, brecciated zones, and joints in the country rock and to have deposited silica, pyrite, and some copper sulphide. Later surface waters oxidized the sulphides and set the gold free. The original deposition was without much doubt an impregnation of the country rock, as is the case with the secondary minerals. There is a notable resemblance between these deposits and those of Kawich and certain of those of Goldfield.

Gold Crater derives its water supply from tanks on the basalt mesa and from two wells, 3 and 9 miles distant. Fuel for mining purposes is obtainable from Stonewall Mountain. Goldfield is 27 miles distant.

OTHER AREAS.

Some of the pegmatitic quartz in the granite 5 miles north of west of Whiterock Spring is stained by limonite, but no other indication of mineralization was noted. It is probable that some of the masses of the older Tertiary volcanic rocks protruding through the later lava flow are worthy of prospecting, but such were not observed in the course of the present work. Prospecting in Pahute Mesa can be most advantageously pursued in the winter or early spring, when water can be obtained from snow or the tanks.

TOLICHA PEAK AND QUARTZ MOUNTAIN.

TOPOGRAPHY AND GEOGRAPHY.

Tolicha Peak, a striking cone rising from Pahute Mesa, is a landmark for miles. Quartz Mountain, a somewhat lower east-west ridge, extends eastward from Tolicha Peak. The hills are bare, except for a sparse growth of desert shrubbery. Monte Cristo Springs, on the western slope, furnish sufficient water for 15 to 20 head of stock.

GENERAL GEOLOGY.

The formations of these mountains from the base up are Cambrian (?) schist, post-Jurassic granite, Tertiary rhyolite, and Tertiary basalt.

SEDIMENTARY ROCKS.

Cambrian (?) schist.—The hill 2½ miles southeast of Tolicha Peak appears greenish gray in color at a distance, and is probably formed of a bluish-gray schistose rock which occurs abundantly in the desert gravels to the south of this hill. The rock is very fine grained, except for some small crystals of biotite and hornblende. White, ellipsoidal areas 1 inch long spot the blue-gray rock. Under the microscope the groundmass appears as an exceedingly fine aggregate of quartz and feldspar, in which are embedded small areas of quartz, orthoclase, ragged hornblende, and biotite. The rock is probably a metamorphosed Paleozoic shale, possibly of Cambrian age.

IGNEOUS ROCKS.

A specimen of rhyolite from Tolicha Peak collected by Mr. S. G. Benedict contains an inclusion of gray granite of medium grain. Post-Jurassic granite probably underlies this peak.

Rhyolite forms Tolicha Peak and the east side of Quartz Mountain. The predominant type is a dense flinty rock of reddish color with a few small phenocrysts of glassy feldspar, quartz, and biotite. Flow lines, perlitic parting, and spherulites are well developed. Gray glassy facies, transparent in thin flakes, are interbedded with this type, as are white or light-gray incoherent facies in which the phenocrysts are abundant and equal the groundmass in bulk. Flow breccias are rather common. This rhyolite is probably about contemporaneous with the earlier rhyolite of the Kawich Range and is presumably of early Miocene age.

Prior to the extrusion of the basalt which covers Pahute Mesa (see p. 137) Tolicha Peak was eroded into a rugged mountain. The valley between Tolicha Peak and Obsidian Butte is upon the contact between the rhyolite and basalt.

STRUCTURE.

The rhyolite of Tolicha Peak is complexly cut by normal faults with displacements of 10 to 50 feet. These faults in some places are less than 100 yards apart. The rhyolite is also intensely jointed.

ECONOMIC GEOLOGY.

The rhyolite around Monte Cristo Springs is kaolinized or silicified. Prospect holes are located on quartz veins in altered rhyolite, the ore being quartz and silicified rhyolite stained by limonite. Quartz Mountain Camp, on the northern slope of Quartz Mountain, was not visited, but the conditions, according to the reports of prospectors, are similar to those at Monte Cristo Springs. The altered masses. which resemble those of Silverbow and are faulted like those of Bullfrog, are outlined on the economic map (fig. 4, p. 43).

MOUNTAINS SOUTHEAST OF PAHUTE MESA.

Southeast of Pahute Mesa are a number of small groups of mountains with crest lines of varying trend, although a number have an eastward extension. These include Shoshone, Skull, Yucca, Timber, and Bare mountains and the Specter Range. Geologically they are characterized by the important development of the early Miocene rhyolite.

SHOSHONE AND SKULL MOUNTAINS AND THE HILLS IN THE VICINITY.

TOPOGRAPHY AND GEOGRAPHY.

Shoshone and Skull mountains lie to the north of the Specter Range and the Skeleton Hills and to the east of Fortymile Canyon. Shoshone Mountain is joined to the Belted Range by a low gap, but from its east-west trend it more properly belongs with the other ridges in the vicinity. Shoshone (7,540 feet) and Skull (6,100 feet) mountains are each capped by horizontal lava flows, and in consequence from a distance appear as mesas. The other hills and ridges vary in form from the jagged ridges of Carboniferous rocks to the smooth depressed domes of the Siebert lake beds. The various ridges and hills are in many instances separated from one another by opposed valleys which are filled with desert gravels.

A fairly heavy growth of juniper and piñon is found on the north slope of Shoshone Mountain above Tippipah Spring, but other portions of this mountain and the other ridges are bare except for sparse groves of the tree yucca and here and there a Spanish bayonet (*Yucca aloifolia?*). Scarcely a spear of grass grows throughout these hills. Of the four springs in these hills, Cane Spring flows about 1,500 gallons a day; Tippipah contains from 50 to 100 gallons of standing water; Topopah (or Blackrock) flows from 15 to 25 gallons a day, and the fourth, which lies 4 miles south of Cane Spring, is small and is dry in summer.

GENERAL GEOLOGY.

The formations of these hills, from the oldest to the youngest, are the following: Carboniferous (Pennsylvanian) sedimentary rocks, quartz-monzonite porphyry, earlier rhyolite, Siebert lake beds, later rhyolite, and basalt.

SEDIMENTARY ROCKS.

Pennsylvanian limestone.—Pennsylvanian limestone forms the ridge to the northeast of Tippipah Spring and the northern face of the ridge northwest of Yucca Pass. A third area of limestone, 6 miles south of Tippipah Spring, outcrops between the desert gravels below and the later rhyolite above. Limestone pebbles are abundant in the Siebert lake beds, and small inclusions occur in the quartz-monzonite porphyry and the earlier rhyolite. This limestone is similar to that of the Belted Range. (See p. 121.)

Siebert lake beds.—Siebert lake beds form the northern and northeastern faces of Shoshone Mountain, rim the southern edge of Skull Mountain, and cover areas 4 miles southeast of Tippipah Spring and 4 miles south of Cane Spring. Somewhat over 1,000 feet of lake beds are exposed on the north side of Shoshone Mountain, a section being as follows:

Section on north side of Shoshone Mountain.

	Feet.
White (locally yellow through iron stains), fine-grained, incoherent, impure sandstone. Bedding planes near the base 100 feet apart. Crystals of biotite, glassy feldspar, and quartz occur in upper 200 feet. Some bands contain pebbles of glassy rhyolite less than 3 inches in diameter	650
Same, but without the small crystals. Some pink layers. Bedding planes well developed from 40 feet to 1 foot or less apart. Pebbles of glassy rhyolite up to 3 inches in diameter occur in certain beds	100
Same, with pebbles of Carboniferous limestones and quartzites one-fourth inch in diameter	200
Same, with abundant crystals of biotite, glassy feldspar, and quartz. Pebbles up to 4 inches in diameter, largely of glassy or semipumiceous rhyolite	100

In other areas these sediments are more brilliantly colored, pinks and reds not being unusual. The bowlders of the conglomeratic beds in some instances reach a diameter of 5 feet. In addition to the pebbles already mentioned, others are present of quartz-monzonite porphyry, the earlier rhyolite, and a vesicular basalt. The basalt was not seen in place, but is perhaps contemporaneous with the earlier rhyolite and corresponds to the earlier basalt of the Amargosa Range. The Siebert lake beds, which characteristically form depressed domes, break down readily into a sand. Huge globular cavities, due in part to exfoliation and in part to wind erosion, and pillars capped and protected by huge bowlders add fantastic elements to many hills. Joints affect only the minor topographic features. In certain instances silicification has followed joints and chalcedony has been deposited in their fractures. Such joints, being resistant, weather in relief.

The Siebert lake beds appear to have been deposited in a lake of some depth, to which much fragmental material was carried. The size of the material varied considerably from time to time, the variation in coarseness being an expression in part of the depth of the lake and in part of the topography of the lake shores. Much of the material was derived from disintegrating rhyolite, but at times there were apparently also explosive rhyolitic eruptions, which threw into the lake many small crystals of biotite, feldspar, and quartz. The sediments on Shoshone Mountain overlie the quartz-monzonite porphyry and earlier rhyolite unconformably and are overlain apparently conformably by later rhyolite, while on Skull Mountain the basalt overlies them unconformably. They are without much doubt to be correlated with the Siebert lake beds at Tonopah[a] of Miocene age.

IGNEOUS ROCKS.

Quartz-monzonite porphyry.—Quartz-monzonite porphyry is the predominant formation in the hills to the east, north, and northeast of Cane Spring. The texture of the rock indicates that it was probably intruded in older rocks, which are, however, not at present exposed.

The quartz-monzonite porphyry has a gray or greenish-gray, finely crystallized or lithoidal groundmass, which is somewhat subordinate in bulk to the phenocrysts. The latter include feldspar, usually altered but in rare instances fresh and then clearly striated; biotite, fresh to altered, and serpentinized hornblende. In many cases hornblende is very subordinate to biotite. The feldspars reach a maximum length of one-fourth inch; the other phenocrysts are slightly smaller. The microscope shows that the rock is a quartz-monzonite porphyry almost approaching granodiorite porphyry. The groundmass consists usually of a microgranitic, but over small areas micropegmatitic mosaic of orthoclase, quartz, and a little plagioclase. The plagioclase phenocrysts, complex crystals, are usually twinned according to the Carlsbad law and many of them are zonally built. One determination proved this mineral to be basic andesine. A few phenocrysts of quartz, deeply embayed by magmatic corrosion, and of orthoclase are also present, in addition to the phenocrysts microscopically determined. Magnetite, zircon, and apatite are present as accessory minerals. The secondary minerals include kaolin and epidote after the feldspars, chlorite and epidote after biotite, and pseudomorphs of serpentine after hornblende or possibly augite.

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[a] Spurr, J. E., Prof. Paper U. S. Geol. Survey No. 42, 1905, p. 54.

The rock resembles lithologically and in its stratigraphic position the monzonite porphyry of the Kawich Range, and the two rocks are doubtless approximately contemporaneous. Each is strikingly similar to the quartz-monzonite porphyry of Stonewall Mountain. The porphyry of Skull Mountain and that of the Kawich Range are older than a rhyolite, which is supposed to be of early Miocene age. The quartz-monzonite porphyry also closely resembles rocks which on the western border of the area surveyed appear to be a variant of the post-Jurassic granite magma. While it is possible that they are pre-Tertiary in age they are here tentatively assigned to the late Eocene.

Earlier rhyolite.—The earlier rhyolite and its kaolinized and iron-stained alteration products form the Calico Hills, remarkable for their brilliant pink, red, and white coloring. A number of smaller areas lie in the group of hills in which the Horn Silver mine is situated, and some of the rhyolite to the west of Yucca Pass may possibly belong to the earlier series.

The earlier rhyolite includes a number of facies, most of which are characterized by abundant phenocrysts that equal or exceed the groundmass in bulk. The groundmass is white or gray in color and is usually dense. The phenocrysts are of medium size. Tabular crystals of glassy unstriated feldspar and rounded grains of slightly smoky quartz are much more abundant than the somewhat smaller hexagonal plates of black mica. Other facies are black glasses with perlitic parting, but without phenocrysts, and gray glasses with a few quartz phenocrysts. The rock is a flow, since certain beds show distinct flow banding and others contain many fragments of rhyolites and are evidently flow breccias.

The earlier rhyolite appears to lie upon the uneven surface of the quartz-monzonite porphyry. The later rhyolite apparently overlies the earlier, while pebbles of the earlier rhyolite are contained in the Siebert lake beds. The same relations exist in the Kawich Range, and the earlier rhyolites of the two ranges are doubtless approximately contemporaneous and of early Miocene age.

Later rhyolite.—The later rhyolite flow overlies the Siebert lake beds on Shoshone Mountain, while several small masses to the south of Cane Spring cap the same formation. In the latter locality the former extension of the rhyolite was much greater and the southward-dipping flow of the Shoshone Mountain may at one time have been connected with it. The rhyolites west of Yucca Pass are, from their lithologic character and relation to the Siebert lake beds, probably to be correlated with the later rhyolite.

Southwest of Tippipah Spring 275 feet of the later rhyolite overlies the Siebert lake beds, while near the center of Shoshone Mountain about 1,500 feet of rhyolite is exposed. At the first locality the lower 250 feet is a dense brownish-pink rock with sparse and small phenocrysts of glassy feldspar, biotite, and quartz. Some flow bands are purple or gray in color, others are vesicular, and still others carry numerous small inclusions of rhyolite, and are in consequence flow breccias. Vertical columnar joints, originating during the cooling of the magma, are not unusual. The broadest columns are 4 feet in diameter. Above this is 15 feet of a black glass, in which the phenocrysts exceed the groundmass in bulk. This in turn is overlain by 10 feet of rhyolite like that first described, except that the phenocrysts are larger and more numerous. In it are thin bands of the black glassy variety. At the south end of Shoshone Mountain similar facies occur, and in some of these the flow banding is strongly developed, the flow lines, as a rule, being straight, although in places wavy.

The later rhyolite south of Cane Spring is a yellowish-brown rock with lithoidal or chalky groundmass, which is equal in bulk to the phenocrysts. These include medium-sized glassy unstriated feldspar and slightly smoky quartz, together with abundant but tiny biotite phenocrysts. The rhyolites west of Yucca Pass are waxy-lustered glasses and well-banded, phenocryst-rich flow breccias of purplish color. In the latter gray spherulites occur.

The later rhyolite ordinarily forms buttes and mesas, since the various flow bands vary considerably in resistance to erosion. Like the later rhyolite of the Kawich Range, the later rhyolite of these hills overlies the Siebert lake beds. The two, which are rather similar lithologicaly, are probably about contemporaneous and are of late Miocene or early Pliocene age.

Basalt.—A basalt flow caps Skull Mountain, a number of small areas occur to the east of the Calico Hills and to the west of the Horn Silver mine, while three small hills lie 4 miles east of the iron tank in Fortymile Canyon. Basalt also occurs between Fortymile Canyon and Shoshone Mountain. It is a dense black or dark-gray rock with sparse phenocrysts of glassy striated feldspar and slightly altered glassy olivine. Both the vesicular and nonvesicular facies previously described in other ranges occur. The nonvesicular basalt weathers into spheroidal masses, while the vesicular facies usually break down into slabs which are elongated parallel to the flow banding. A single thin section of a dense, slightly vesicular facies proved on microscopic examination to be composed of dark glass containing many laths of a calcic plagioclase and grains and partial crystals of olivine more or less altered to reddish-brown serpentine.

On Skull Mountain the basalt lies upon the eroded surface of the Siebert lake beds, while in the low isolated hills 4 miles east of the iron tank it appears to overlie the later rhyolite. It is without doubt the youngest formation of these hills, and is probably of late Pliocene or early Pleistocene age.

STRUCTURE.

The Pennsylvanian limestone is folded into rather open folds, the dips of which rarely exceed 45°. The predominant axes trend from northeast to southwest, although minor folds with east-west axes also occur. The ridge to the northeast of Tippipah Spring is synclinal in structure. The Pennsylvanian rocks appear to have had a rather uneven surface prior to the deposition of the Siebert lake beds. Not only do many of the lake beds contain large bowlders of limestone, but west of Tippipah Spring a number of hillocks of the older limestone protrude through the Tertiary sediments.

In a broad way the Siebert lake beds and the later rhyolite are slightly flexed and the beds on Shoshone Mountain dip gently to the south. Normal faults of 50 feet displacement are not unusual in the tuffs. The latest deformation is that of the basalt. On Skull Mountain it dips gently to the south, while on the ridge to the east it dips with a similar angle to the north, the two blocks being separated by a north-south fault.

ECONOMIC GEOLOGY.

The quartz-monzonite porphyry and the earlier rhyolite have been silicified and kaolinized in restricted areas, the silicification being comparable to the alterations in the vicinity of Kawich and the kaolinization to those of Silverbow. These areas, which are worthy of prospecting are delineated in fig. 4 (p. 43). The quartz-monzonite porphyry near the Horn Silver mine has not only been altered to a spongy mass of brownish-gray silicified porphyry like that of Kawich, but it is cut by quartz stringers with associated gypsum. Other veins and irregular cavities are partially filled with chalcedony, which in turn is incrusted by quartz crystals. The rhyolite of the Calico Hills has been in places intensely silicified. The silicified rhyolite 2 miles north of the Horn Silver mine is cut by thin quartz seams. A similar yellow stain (a basic ferric-alkali sulphate?) to that noted near the prospects at Silverbow is present on joint surfaces.

SPECTER RANGE AND SKELETON HILLS.

TOPOGRAPHY AND GEOGRAPHY.

The hills in the southeast corner of the area surveyed may be considered as the westward extension of the irregular Spring Mountain Range. They consist of a number of mountains and hills now isolated from one another by narrow canyons and broad valleys filled with desert gravels. The ridges and hills are rugged and sharp and are crowned by many peaks. The highest point (5,800 feet above sea level) is in the southeast corner of the area. The presence of many inlying hills near by indicates that those portions of the old mountain mass partially buried by desert gravels possessed an equally dissected topography. A majority of the hills are elongated parallel to the strike of the Paleozoic rocks. West of the road between Cane Spring and Ash Meadows ridges with northeasterly trend predominate, and east of the road lie irregular massive groups of hills. The hills stop abruptly along a north-south line east of Fortymile Canyon, and prior to the inwash of detrital material this canyon must have been a strikingly prominent topographic feature. The hills are bare of timber and destitute of springs.

GENERAL GEOLOGY.

The formations of these hills, from the oldest to the youngest, are Prospect Mountain quartzite, Prospect Mountain limestone,[a] and basalt.

SEDIMENTARY ROCKS.

Prospect Mountain quartzite.—Two areas of quartzite, one large and the other small, cover 20 square miles near Point of Rocks. The formation, 2,000 to 3,000 feet thick, underlies the Prospect Mountain limestone conformably, with transitional beds between the two. The rock, either a quartzite or an indurated sandstone, varies in color from gray to purplish red and in grain from fine quartzite to conglomerates, with pebbles one-fourth inch in diameter. The pebbles include white quartzite, red and brown jasperoid, and white, smoky, or opalescent quartz of vein or pegmatitic origin. The rocks are rather constantly impure and grade through arkoses into minor beds of red and green slaty shale. The coarse-grained arkose resembles granite on first sight. The quartzite is usually considerably jointed.

This rock appears to have been deposited in a comparatively shallow sea, to which much fragmental material was carried. From its position, conformably beneath Cambrian limestone, this quartzite is undoubtedly to be correlated with the Prospect Mountain quartzite,[b] of lower Cambrian age.

Prospect Mountain limestone.—The Prospect Mountain limestone is the predominant rock of the Specter Range and the Skeleton Hills. It is typically light to dark gray, compact, crystalline, and fine grained. Some beds have a conchoidal fracture and are almost as compact and fine grained as lithographic limestone. Pinkish gray varieties of medium grain also occur, but are rather unusual. Cross-bedding is observed in places. The beds are typically massive, although certain horizons are thin bedded. On weathering the various beds assume red, yellow, and gray colors of varying tints, rendering the mountain structure legible at great distances. Near the middle of the section, as exposed, are a few layers of black chert, while a bed of quartzose sandstone, 20 to 30 feet thick, occupies a similar position in the more northerly hills east of Fortymile Canyon. This rock, locally a quartzite, is white or pinkish white and fine grained.

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[a] See note, p. 28.

[b] Hague, Arnold, Mon. U. S. Geol. Survey, vol. 20, 1892, p. 35.

The formation appears to be between 5,000 and 6,000 feet thick. It was deposited in a sea of medium or shallow depth, in which depression of the sea bottom kept pace with deposition and into which little detrital material was introduced. A few poorly preserved fossils were collected north of the Skeleton Hills. Mr. E. O. Ulrich reports that these consist of trilobite fragments and a valve of a brachiopod, probably referable to the genus *Billingsella*. He believes that they are of Cambrian age. The limestone is without much doubt the Prospect Mountain (Cambrian) limestone of Eureka, Nev.,[a] although the upper portions may belong more properly with the Pogonip limestone.

IGNEOUS ROCKS.

In no other equal area surveyed during this reconnaissance do igneous rocks cover so little territory. The writer saw no indications of granite or other intrusions, an observation verified by statements of several prospectors who have examined the hills in considerable detail. A single small butte of vesicular basalt similar to that of the mesa south of Cane Spring protrudes from the desert gravels northeast of Point of Rocks. This butte is probably an erosional remnant of a flow which extended from this mesa southward.

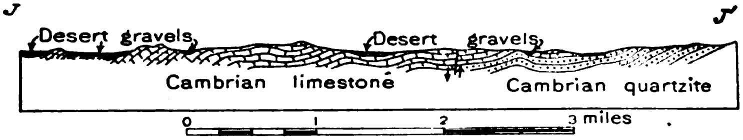

FIG. 15.—Northwest-southeast section through Specter Range.

STRUCTURE.

The Cambrian rocks are folded in a complex manner. Two sets of folds are present in almost equal development, the axes of one striking northeast, those of the other striking east and west. Zones of brecciation and normal faults occur at a number of places, but few of the faults show a displacement of more than 30 feet. The fault 2 miles north of west of Point of Rocks is normal and has a displacement of 100 feet. It trends N. 30° E. and the western side is downthrown. A sag in the hills coincides with the fault, the downthrown side being slightly higher than the upthrown. Fig. 15 is a section passing through the hills from northwest to southeast.

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[a] Hague, Arnold, Mon. U. S. Geol. Survey, vol. 20, 1892, pp. 36–38.

ECONOMIC GEOLOGY.

Although the Cambrian rocks are cut by thin veins of white crystalline or banded calcite and by thin quartz veins, apparently barren, they appear to offer slight attractions to the prospector. The Johnnie mine, where strong quartz veins occur, lies 2 miles south of the area surveyed. From information furnished by prospectors it is probably in the Prospect Mountain quartzite.

YUCCA MOUNTAIN.

TOPOGRAPHY AND GEOGRAPHY.

Yucca Mountain is so called from the groves of the tree yucca which cover its lower slopes. The group lies between Fortymile Canyon on the east, Beatty Wash on the north, Oasis Valley and Crater Flat on the west, and the Amargosa Desert on the south. The mountains of the main east-west ridge are gently sloping domes with rugged summits, the highest of which is 6,700 feet above sea level. The ridge drops rather suddenly to Fortymile Canyon on the east, but on the west it descends gently and merges with Bare Mountain. From the main east-west ridge mesa tongues extend southward to the Amargosa Desert, rhyolite being the predominant rock. Yucca Mountain is colored dull tones of gray, brown, red, and yellow. Near the summits the varying resistances to erosion of the rhyolite flow beds are expressed in cliffs and gentle slopes. Spires tend to form where vertical joints are well developed. The mesa tongues to the south become lower toward the south-southeast, the surface being determined by resistant lava flows. The eastern side of these mesa tongues passes beneath the Recent alluvial deposits, while the western face is, as a rule, a scarp. The magenta-red basaltic cone 4 miles east of Rose's Well is a prominent landmark. Other volcanic cones are located in Crater Flat and for convenience will be described with Yucca Mountain.

The wide and open character of Beatty Wash between Timber and Yucca mountains is noteworthy. Alluvial deposits cover the depression for a width of 2 miles, although many hills of solid rock protrude from them. The narrowness of the canyon farther downstream is due partly to the more resistant character of the rhyolite to the west. while the width of the upper valley is probably due to the rapid waste of the adjoining high mountain masses on either side.

No water is known in Yucca Mountain. A few junipers and piñons grow on the highest summits of the main ridge.

GENERAL GEOLOGY.

This mountain is composed entirely of igneous rocks, which include the following, beginning with the oldest: Post-Jurassic pegmatite, rhyolite and latite, and basalt.

Post-Jurassic pegmatite.—A single fragment of quartz-feldspar pegmatite was noted in the basalt of the cone 8 miles north of Rose's Well. The basalt in its passage to the surface evidently passed through a mass of pegmatite.

Rhyolite and latite.—The mountain mass, with the exception of a number of rather small basalt areas, is composed wholly of rhyolite and latite. The series includes siliceous volcanic rocks of varying aspect. The brown groundmass in many instances is dense, aphanitic, and opaque, and from the presence of flow banding, perlitic parting, spherulites, and lithophysæ, is evidently of a glassy nature. Gray and black semitransparent glasses also occur. The more altered facies have a gray or white dull lithoidal groundmass and the microscope proves that this also was once a glass that is now devitrified. The phenocrysts are medium sized and usually subordinate to the groundmass; in certain instances they are practically lacking. Slightly smoky rounded quartz individuals and glassy unstriated feldspar crystals are present in equal development; smaller black or bronze biotite crystals are less abundant. In some facies the phenocrysts are all orthoclase, but microscopic examination shows enough quartz in the groundmass to determine their rhyolite nature.

Latites[a] are interbedded with the rhyolites. They are slightly darker in color and contain both striated and unstriated feldspar phenocrysts in approximately equal development. The single specimen examined microscopically proves to be a clear glass, the brownish color of the hand specimen being due to abundant curved trichites radiating from a common center. Perlitic parting is beautifully developed. Phenocrysts of orthoclase and plagioclase of medium composition are each more abundant than biotite. Wedge-shaped titanite crystals, magnetite, and a little hornblende are also present.

Interbedded with the rhyolite and latite flows are porous semituffaceous facies. Flow breccias also occur, the inclusions being of a slightly different rhyolite than that of the main mass. The central portion of the main east-west ridge is probably the site of a vent from which siliceous volcanic rocks flowed. The flows, which extended particularly to the south and west, reach a minimum thickness of 1,000 feet. The series is a continuation of similar rocks of the Bare Mountain group. Presumably it is to be correlated with the rhyolites of the Bullfrog Hills and the Kawich, Belted, and Reveille ranges, and is probably of early Miocene age.

Basalt.—In Crater Flat are two large and one small volcanic cone and a number of low mesa ridges of basalt. A fourth cone is situated

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[a] The use of the term latite is here tentative, since no chemical analyses of the rocks have been made.

4 miles east of Rose's Well. The basalt of the cones is vesicular and dull brick-red or black in color, while in the flow pediment around the cones are dense black facies with a few greenish glassy grains of olivine.

The cones are gently depressed and are usually superimposed upon circular basalt flows. The flows present ropy surfaces, cross fractures produced during the flow of the almost solid mass, and caverns formed by the onflow of the liquid interior after the surface had hardened into a crust, each a characteristic phenomenon of surface lavas which have been but little eroded. The cones themselves are formed in part of flows, but largely of vesicular lapilli, scoriæ, and volcanic bombs. The intimate mixture of these red and black fragments imparts to the cones their magenta-red color. The cone 4 miles east of Rose's Well has on its summit a crater, 300 feet in diameter, which is depressed from 15 to 75 feet below its rim. Sulphur coats the volcanic breccia in the crater. The crater of the cone 7 miles north of Rose's Well has been largely destroyed by erosion, the throat displaying a rubble of vesicular basalt fragments. Beds of fragmental material dip inward toward a common center at the crater of the cone 1½ miles farther north.

Since the eruption of the basalt the cones have been somewhat eroded, calcium carbonate has been deposited in the vesicles, shrubbery has taken root on the lava flows, and a sand dune has been superimposed upon the cone 4 miles east of Rose's Well. The basalt is probably of very late Pliocene or early Pleistocene age.

STRUCTURE.

The rhyolite-latite series has been subjected to mountain-building forces acting in an east-west direction. Joint sheeting and normal faults striking north and south are developed in the mass, while minor joints of east-west strike are also present. The series had been carved into forms approximating those of the present day when basalt eruptions occurred.

ECONOMIC GEOLOGY.

Two small masses of rhyolite whose location is shown on the map (fig. 4, p. 43) are kaolinized and silicified in a similar manner to the rhyolite in the vicinity of ore deposits. Silicification has occurred along joints and in irregular forms, and these resistant masses form the topographic details peculiar to silicified areas of rhyolite. Tunnels have been driven in the larger of the two areas, the ore extracted being a silicified rhyolite slightly stained by limonite. The ore, in part free milling and in part refractory, is said to carry gold with minor silver values. Quartz does not seem abundant in either area.

TIMBER MOUNTAIN.

TOPOGRAPHY AND GEOGRAPHY.

Timber Mountain, named on account of its heavily forested summits, is bounded on the east and northeast by Fortymile Canyon, on the northwest and west by Oasis Valley, and on the south by Beatty Wash. A low divide connects it with Pahute Mesa to the north. The massive mountain has two peaks, each 7,500 feet high, which are separated by a col. The western slope to Oasis Valley is somewhat more gentle than that on the east to Fortymile Canyon. The heaviest forest growth in the area surveyed covers this mountain above an elevation of 6,300 feet. Some of the trees are of sufficient size to be of value as timber.

GEOLOGY.

Timber Mountain appears to be wholly composed of Tertiary rhyolite and basalt, the rhyolite being the older.

Rhyolite.—The mountain peaks and the north and west slopes are formed of rhyolite, which imparts to the mountain a red tone. The most abundant variety is a dense brown or red rock in which the phenocrysts, medium-sized glassy orthoclase and slightly smoky quartz with fewer bronze biotite, equal or exceed the groundmass in bulk. The rhyolite is but an extension of that of Yucca Mountain, and the various facies there noted probably also exist on Timber Mountain. The rhyolite is presumably of early Miocene age.

Basalt.—The rhyolite of Timber Mountain had been eroded into practically its present form when basalt was extruded, filling depressions in the rhyolite and forming level reaches here and there on the mountain. Basalt flanks Timber Mountain on the east, forms the prominent black dome 8 miles east of south of the more northerly of the two peaks, and occurs in several areas on the western slope of the range. The basalt is a dense black or dark-gray rock in which striated feldspar and olivine phenocrysts are prominent. Much of the basalt is vesicular, and the rounded cavities, locally filled by zeolites, vary greatly in size across the flow banding. The basalt flow reaches a thickness of over 1,000 feet. The basalt of Timber Mountain is much younger than the rhyolite, and from the amount of erosion which it has suffered it is believed to be one of the late Pliocene or early Pleistocene basalts.

BARE MOUNTAIN.

TOPOGRAPHY AND GEOGRAPHY.

Bare Mountain, so named on account of its almost total lack of verdure, lies south of Oasis Valley and Beatty Wash, between the Amargosa Desert and Crater Flat. The mountain mass is triangular in form, the apex being at the south end. It is 15½ miles long from north to south and 8 miles wide at the north, its broadest portion. The Bare Mountain hills are comparable to the most rugged portions of the Amargosa and Panamint ranges, the valleys being deep V-shaped troughs and many of the ridges between being knife-edges. Throughout the range the south sides of the gulches are somewhat less steep than the north sides, owing to the prevalent dip to the northeast. The highest point of Bare Mountain, 6,235 feet above sea level, is but 2 miles from the detrital pediment 3,000 feet below. The strongly folded Paleozoic rocks band the mountain with dark and light gray, yellow, white, and red. No water is known in these bare hills.

GENERAL GEOLOGY.

The formations exposed in Bare Mountain, from the oldest to the youngest, are as follows: Pogonip limestone, Eureka quartzite, pegmatite, monzonite porphyry, rhyolite, and basalt.

PALEOZOIC SEDIMENTARY ROCKS.

Bare Mountain is composed largely of Paleozoic sedimentary rocks so strongly folded and faulted that a satisfactory section could not be made in the time at the writer's disposal. The series presented from the top down is probably as follows:

Probable section in Bare Mountain.

	Feet.
Schist	200
Quartzite with some schist and limestone	1,000
Limestone containing near its top a considerable number of beds of schist	3,000–4,000
Quartzite and schist	100–200

At the top of the series the schist, limestone, and quartzite repeatedly replace one another within a thickness of 100 feet. These rocks, particularly at the north end, have been metamorphosed, the original limestone, shale, and sandstone being altered, respectively, to marble, schist, and quartzite.

The limestone in the central part of the range is dark gray to blue-black in color, fine grained, compact, and rather crystalline. Anastomosing veinlets of calcite are characteristic. Much of the limestone is thinly laminated. At the north end of the mountain the limestone is changed to a white or light-colored marble, for the most part rather coarse grained. Weathered surfaces are yellow or brownish in color. Muscovite films are developed on parting planes. The upper and lower quartzites consist of a white or light-gray metamorphosed quartzose sandstone of fine or medium grain and conchoidal fracture. Cross-bedding is common and ripple marks are present in places. In transition to schist the quartzite becomes darker in color, finer in grain, and less pure, some muscovite being present. The original shale of the series, now a silvery or greenish-gray mica schist, is well exposed near Gold Center. The schist is a fine-grained, foliated, and locally crenulated rock composed of micaceous minerals with some quartz and feldspar. Small magnetite and pyrite crystals are common in certain bands and are evidently contemporaneous with the other metamorphic constituents. The planes of schistosity are usually parallel to the bedding planes, which are in places ripple marked, although in certain instances the foliated structure crosses the original bedding at right angles. Weathered outcrops have a typical rusty appearance. A single thin section under the microscope showed a thoroughly recrystallized rock lacking all traces of original structure. The rather well oriented micaceous minerals are muscovite, biotite, and limonite-stained chlorite, and grains of quartz and orthoclase lie between their blades. Tiny magnetite crystals and grains are abundant.

The lower limestone member of the series was deposited in a sea of medium depth, into which for a long period little or no fragmental material was carried. The upper portion of the series, on the other hand, was deposited in a shallow sea which at times received fragmental material of varying grain. The quartzites and schists mark periods in which the deposition of fragmental material exceeded organic and chemical sedimentation, while the interbedded limestones indicate a reversal of the dominant process. A few poorly preserved fossils (one of which is identified by Mr. E. O. Ulrich as a gasteropod suggesting *Eccyliopterus* or some other euomphaloid genus) were obtained from Bare Mountain, and although by no means diagnostic of the age of the series, they are probably younger than the Cambrian and older than the Carboniferous. The basal quartzite may be an intercalated bed in the Pogonip limestone or possibly may represent the Hamburg shale of the Eureka section. The thick limestone on lithologic grounds is correlated with the Pogonip (Ordovician) limestone, while the overlying quartzite is probably the Eureka (Ordovician) quartzite of Hague.[a] This upper quartzite and schist rather closely resemble the Eureka quartzite of the Kawich Range. The area covered by the two formations is roughly indicated on the map (Pl. I), but future work will prove the distribution much more complex.

IGNEOUS ROCKS.

Post-Jurassic pegmatites.—Pegmatitic dikes from 2 inches to 4 feet thick are common in the northern part of the range. The most widely distributed type is composed of white or very light pink feldspar, with some colorless quartz and muscovite. None of the individuals exceed a diameter of one-half inch. A less common variety is a glassy quartz in which are many biotite flakes one-eighth inch in diameter. A few black tourmaline rods up to one-fourth inch long occur in a quartz-rich muscovite pegmatite. While some of the tourmaline occurs in nests of clustered rods, some also forms along minute cracks and appears to be of pneumatolitic origin. Pegmatitic quartz veins with small quantities of feldspar and muscovite are very common, and it is probable that many of the older quartz veins were deposited by waters from the granite magma. The pegmatite dikes cut Paleozoic rocks and are included in the Tertiary volcanic rocks, and are probably post-Jurassic in age. They closely resemble the pegmatites west of Bullfrog.

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[a] Hague, Arnold, Mon. U. S. Geol. Survey, vol. 20, 1892, pp. 54–57.

Diorite porphyry.—Bowlders of the biotite-monzonite porphyry or diorite porphyry occur on an alluvial fan at the northwest edge of Bare Mountain. Dikes of this rock, possibly of pre-Tertiary age, probably cut the Paleozoic rocks.

Tertiary rhyolite and basalt.—Flows of rhyolite and basalt form the north end of the Bare Mountain hills. These are similar lithologically to the rhyolite and later basalt of the Bullfrog Hills. (See pp. 180–181.)

STRUCTURE.

The Paleozoic rocks of Bare Mountain form a faulted monocline, the beds of which strike from north of west to northwest and dip from 15° to 80° NE. Superimposed upon the monocline are minor cross folds. The schist and in a less degree the limestone are closely crenulated and small isoclinals and overturned folds are common. The folding was so intense that schist bands between limestone and quartzite are severed on the limbs of the folds and greatly thickened at the crests and troughs. At least two profound normal faults of over 1,000 feet displacement cut the Paleozoic rocks, and other faults of almost equal magnitude exist. Small faults, both normal and reverse, are common. Joints traverse all the formations, but are particularly developed in the quartzite, which in consequence breaks down into squared blocks.

Prior to the extrusion of the Tertiary rhyolite the range stood out boldly and was probably as high or almost as high as at present. The differential movement which has occurred at the contact of the Paleozoic and Tertiary rocks is unimportant.

ECONOMIC GEOLOGY.

Quartz veins are common in the north end of the range, and mineral locations were made on some of them early in 1905. Older veins, which were folded with the Paleozoic rocks, are cut and faulted by a younger set. All the quartz veins are characterized by rather abrupt variations in width.

The Decillion claim is located in the northwestern portion of the range near the mouth of a deep canyon. The principal development work is a 50-foot shaft. Quartz veins and stringers reaching a maximum thickness of 1 foot cut limestone and schist. Some of the veins strike east and west and dip 45° S. Chalcopyrite in grains up to one-half inch in diameter is disseminated through the quartz. Malachite and a little azurite stain the quartz around the sulphide and have been deposited in cavities in the quartz. The quartz vein since its deposition has been faulted and crushed, the fragments being in places cemented by granular gypsum, while gypsum crystals line some cavities. The ore of this mine is said to run high in silver, with low gold values.

The two 50-foot shafts of the Kismet Mining Company, better known as the Lonsway property, are situated on the crest of a high ridge 1½ miles southwest of Beatty. The country rock here, a quartzite, strikes N. 35° W. and dips 15° NE. The quartz vein, which is traceable for several hundred feet, is from 1½ to 2 feet wide and strikes N. 85° W. and dips 55° S. The quartz has a sparry texture and is white except at the surface, where it is heavily stained by limonite and hematite. This vein is said to have been locally charged with gold, probably derived from pyrite which occurs with limonite in quartz at the bottom of the shaft. The quartzite near the vein is sheeted. Silver ores with purple-fluorite gangue occur at the Lige Harris prospect. In other portions of the range the quartz veins contain galena cubes.

The quartz and associated sulphides were deposited in open east-west fissures, possibly by granite magmatic waters. Later the veins were faulted and crushed, and surface waters have more or less completely altered the sulphides to oxides and carbonates, forming free-milling ores.

The mines on Bare Mountain are controlled by practically the same economic conditions as those of the Bullfrog district. Good water can be obtained in the springs of Amargosa River one-half mile away. The most accessible wood is that of the Amargosa Mountains, 25 miles distant. The mines are 1 to 3 miles from the proposed railroad to the Bullfrog district.

SARCOBATUS FLAT.

Sarcobatus Flat lies west of Pahute Mesa and east of the Amargosa Range and Slate Ridge. It is one of the largest valleys in the area surveyed, being 32 miles long and having an average width of 10 miles. It has very gently graded slopes. Near its center, at an elevation of 3,950 feet, is a large playa, and two small playas lie in the arm of the valley south of Tolicha Peak. The surface of the larger playa is slightly roughened by erosion, but the total difference of altitude over the entire flat is probably less than 20 feet. A few lime-carbonate concretions of rude cylindrical form are embedded in the playa clay. Similar concretions occur in the playa clay of the Alkali Spring flat.

Adobe bricks have been made from the playa clay at several places, and it is probable that the clay of all the playas is well adapted to their manufacture. Borax is said to have been leached from the clay of this flat 3 miles south of east of Montana Station. The industry was never extensive, and until the rich bedded deposits of borax minerals are exhausted these playa deposits will be commercially unimportant. A number of wells, sunk in or near the large playa, have uniformly obtained water. In the center of the playa the surface and the water table are practically at the same level (see fig. 2, p. 21). The coyotes scratch holes from 2 to 3 feet deep in the clay and get water. The water is adequate for domestic and stock purposes and for the most part pure, although some is brackish and that in one well is unfit for use. Water was obtained at the following depths in the various wells: Forks of Goldfield-Bullfrog and Goldfield-Beatty roads, 180–190 feet; Farmer Station, 8–10 feet; Thorp's mill, 30 feet; Montana Station, 18 feet; Summerville, 1 mile south of Montana Station, 8–9 feet; Tonopah Well, 10–12 feet, and Seattle Well, 40–50 feet. Mr. E. L. Rickard reports that the water at Montana station occurs in a layer of quicksand.

AMARGOSA DESERT.

The Amargosa Desert is one of the most extensive depressions in the Great Basin. The main valley heads against the Amargosa Range and Bullfrog Hills, south of Sarcobatus Flat, with which it is connected by a thin ribbon of Recent gravels, and trends southeast to Ash Meadows, and thence south 60 miles to a point where it swings around the Funeral Mountains to join Death Valley. Within the area mapped the valley is about 10 miles wide at the north end, contracts in the middle, and expands to a width of 21 miles at the southern border of the area. The valley sends branches well into the surrounding mountains. From the summit south of Currie Well the valley descends 1,600 feet in 10 miles and but 500 feet in the next 20 miles. The cross section of the valley is comparatively flat except in the northern part. The lowest portion within the area shown on the map lies at an elevation of 2,500 feet. The channels of the so-called Amargosa River and of Fortymile Canyon, each characterized by bowlders and coarse gravel, are slightly depressed beneath the surface of the valley. The valley is without grass, but is covered with a sparse growth of creosote bush and other shrubbery, while mesquite trees grow north and east of Ash Meadows.

The Recent detrital deposits in the southern portion of the valley are fine grained, and the wind has heaped these into dunes. The most important group of sand dunes, 3 miles south of Rose's Well, is shown on the map. The Amargosa mine at Rhyolite has been sunk 330 feet in Recent gravel, and in some portions of the valley the Recent alluvial deposits are probably 500 or more feet deep. Inliers of Tertiary and Paleozoic rocks are, however, common. Many hills and ridges of Paleozoic limestone protrude from the gravel in the southeast corner of the area. The line of Paleozoic inliers northwest of the sand dunes is probably the crest of a ridge formerly connected with the Amargosa Range, but now separated from it by a mantle of detrital material.

The springs at Ash Meadows have already been described (p. 20). Water has been obtained at the following depths in three wells in the valley: Rose's Well, 208 feet; Miller Well No. 1, 183 feet; Miller Well No. 2, 70 feet. The water in all cases is good, although that of Rose's Well has a slight saline taste. The log of Miller Well No. 1, as reported by Mr. W. F. Miller, is as follows:

Log of Miller Well No. 1, Amargosa Desert.

	Feet.
Gravel	2
"Cement," indurated gravels	70
Gravel	4–6
"Cement"	10–12
Sand	6–7
"Cement"	78
Gravel (water stratum)	11

Playa and alluvial slope deposits of the older alluvium outcrop in a number of places in the Amargosa Desert, and these beds probably underlie at no great distance the south end of the valley. The hills in the desert 8 miles south of Bullfrog are composed of angular and subangular bowlders and sand derived from the surrounding hills, and among other rocks basalt occurs. The material closely resembles that of the present alluvial slopes. It has been eroded into hills, and its bowlders are somewhat weathered. It is without doubt an alluvial slope contemporaneous with the playa deposits next described. South of Rose's Well exposures of ancient playa deposits are common, and the northern border of the old playa appears to have been north of this well. At the southern border of the area surveyed this playa was probably 20 miles wide. The deposits now occur as low, white domes and dissected mesas, which are particularly abundant southeast and east of Miller Well No. 2. Six miles west of the Big Dune the deposits consist of fine-grained clay, in which are embedded many grotesque lime-carbonate concretions. Bedding planes are rare, but appear to be horizontal. The small deposit 1 mile north of Rose's Well is similar except that a few small, well-rounded pebbles occur in the clay and that a 1-foot layer of white porous limestone is interbedded with it. These beds at Ash Meadows form white limestone-capped mesas and buttes, which are landmarks for miles. A section of the bluff north of Ash Meadows is as follows:

Section of bluff north of Ash Meadows.

	Feet.
1. White, carious, dense limestone, with many lenticular openings parallel to the bedding. The limestone is finely banded parallel to these openings and has the characteristics of chemically precipitated limestone	10
2. White, fine-grained clay, massive, inclosing small crystal aggregates of selenite	40
3. Limestone like No. 1	1
4. Clay like No. 2	20
5. Limestone like No. 1	½
6. Clay like No. 2	30

These beds lie horizontal, although Campbell[a] states that farther south they dip to the west. The playa deposits and gravels are without doubt members of the older alluvium, which is considered in part of late Pliocene and in part of Pleistocene age.

AMARGOSA MOUNTAIN SYSTEM.

The Amargosa Mountain system, including the Amargosa Range, Gold Mountain, Slate Ridge, and the Bullfrog Hills, is the most important uplift in the area under discussion. The mountain mass, which has a northwesterly trend, lies between Death Valley on the west and Sarcobatus Flat and the Amargosa Desert on the east. Geologically this mountain system is characterized by the widespread distribution of early Paleozoic rocks and in its northern portion by the presence of granite.

AMARGOSA RANGE.

TOPOGRAPHY AND GEOGRAPHY.

The mountain range between Sarcobatus Flat and the Amargosa Desert on the east and Death Valley on the west is designated the Amargosa Range by the United States Geographic Board, which also calls that portion of the range north of Boundary Canyon the Grapevine Mountains and that south of the canyon the Funeral Mountains. The mountain range as a whole is a unit, the most natural division on physiographic and geologic grounds being at Furnace Creek, south of the area surveyed, as suggested by Spurr.[b] The range here changes its trend; moreover, to the south of Furnace Creek it is composed principally of Tertiary sedimentary rocks and to the north of much older rocks.

The sinuous crest line of the Amargosa Range trends N. 40° W. and roughly coincides with the California-Nevada boundary line.

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[a] Campbell, M. R., Bull. U. S. Geol. Survey No. 200, 1902, p. 14.

[b] Spurr, J. E., Bull. U. S. Geol. Survey No. 208, 1903, p. 187.

The northeastern side of the range is not impressive, the crest line rising only 2,000 to 4,000 feet above the Amargosa Desert and Sarcobatus Flat. On the other hand, the crest is from 5,000 to 7,000 feet above Death Valley, and in consequence the southwestern slope is steep, deeply cut by canyons, and set with numerous rugged peaks and pinnacles. The ridge culminates near its north end in Grapevine Peak, 8,705 feet above sea level. Wahguyhe Peak, with an elevation of 8,590 feet, is a magnificent truncated cone.

The Amargosa Range from Death Valley presents a somber appearance, the grays and blacks of the Paleozoic rocks predominating. The northern and middle portions of the range, as seen from the Amargosa Desert and Sarcobatus Flat, are colored by the rather brilliant reds, yellows, white, and grays of rhyolite flows.

The valleys heading in the range from the east are wide and gently sloping, and in some places, as at Indian Pass, broad detritus-filled embayments extend almost to the range crest. The stream channels on the southwestern side of the range are deep canyons, which, near the higher peaks, are sunk 3,000 feet beneath the sharp ridges on either side. The tortuous stream bed of Titus Canyon is only 40 feet wide, and from it the rocks rise sheer 200 feet, while the slope to the ridges 2,000 feet above is very steep. The canyon walls to a height of 40 feet are water polished, and cloudbursts have recently lodged bowlders 50 feet above the stream bed. The smoother reaches of the stream gradient are separated by transverse rock walls from 10 to 100 feet high. These barriers, which in most regions would cause waterfalls, are formed of resistant rock strata.

The eastern side of the range, from Chloride Cliff southward to the boundary of the area here discussed, is topographically older than the rest of the range, being a land surface to be correlated with similar tracts in the Panamint, Belted, and Kawich ranges. (See pp. 99, 119, 202.) A smaller area of this older topography is situated north of Thimble Peak. These portions of the range are characterized by dome-like mountains, shallow and gently sloping valleys, deep soil, and comparatively few and inconspicuous rock exposures. The area north of Thimble Peak is surrounded by deep-cut canyons, and the drainage lines pass precipitously from the mature upland to the young gulches. This mature topographic surface at one time extended over the whole mountain range, but is now preserved only where advantageously situated. Since it forms the eastern slope of the range south of Chloride Cliff and is not present on the western slope, it may be inferred that the grade of the streams on the west has been greatly increased by a rather recent depression of Death Valley. This depression occurred probably in early Pleistocene time, since a similar surface in the Panamint Range was developed before the outflow of late Pliocene or early Pleistocene basalt. (See p. 202.)

The crest of the Amargosa Range above 6,000 feet, at a distance of 8 miles northwest and southeast of Grapevine Peak, is partly covered by a sparse growth of piñon and juniper. The largest trees are 1½ feet through and from 20 to 25 feet high. The Paleozoic rocks to the west of the crest line are bare even above an elevation of 6,000 feet. Some grass grows in the higher valleys on the northeastern slopes of the range. South of Chloride Cliff the Grapevine Mountains have but few springs, and the largest of these is said to be poisonous and is shunned by the Indians. North of Chloride Cliff springs are comparatively abundant. The largest of these, Keane Spring, flows about 1,350 gallons per day; the two Willow springs and Daylight Spring, from 500 to 1,000 gallons each. The other springs are smaller, Hole in the Rock, when full, containing only about 10 gallons.

GENERAL GEOLOGY.

The formations exposed in the Amargosa Range, from the oldest to the youngest, are as follows: Prospect Mountain quartzite (?), Pogonip limestone, Eureka quartzite, Lone Mountain limestone, post-Jurassic granite, pre-Tertiary diorite porphyry, biotite andesite, earlier rhyolite and contemporaneous basalt, Siebert lake beds, later rhyolite and biotite latite, and basalt.

SEDIMENTARY ROCKS.

Prospect Mountain quartzite (?).—The Amargosa Range south of a line somewhat north of Chloride Cliff is formed of a series of quartzite beds with intercalated schists and marble. The large hill group north-northeast of Lee's Camp and the small boss-like hills northwest of the Big Dune are of the same formation. This series, which includes several thousand feet of sedimentary rocks, is considerably metamorphosed, the alteration being more evident in the schists and the quartzites than in the marble.

The quartzites are usually white, pink, or gray in color, although on the one hand a cement of specular hematite and on the other much clayey matter in the quartzite change the color to black. The normal, rather pure quartzose rock is fine to medium grained, and is in many places thin bedded. Cross-bedding and ripple marks are locally present. The quartzite passes into conglomerate with well-rounded pebbles, which reach a maximum diameter of one-half inch. The pebbles are of quartz, of vein or pegmatitic origin, white quartzite, black jasperoid, and schist. The development of sericite, particularly in the conglomeratic facies of the quartzite, imparts a greenish tinge to the rock. On microscopic examination this sericite proves to be contemporaneous with the quartz cement, which secondarily enlarges the clastic grains of quartz. Mashing, besides developing sericite, has locally elongated the pebbles of the conglomerate, forming a schistose conglomerate.

The more impure quartzite grades into slaty shales and schists. The shales are fine grained and of a greenish or dark-gray color, with laminæ from one-sixteenth to one-half inch thick. The slaty shale has usually a few muscovite plates on its parting planes and passes, with gradations, into fine-grained bluish or greenish-gray sericite schists. The schistosity is usually parallel to the original bedding of the rock, but in places cuts it at all angles. In the schist deep-red garnets, small tabular hexagonal greenish plates (ottrelite), greenish-gray micaceous aggregates (chlorite), or grayish prisms (andalusite) are developed. Under the microscope these schists appear without original structures. Fine shreds of sericite, with chlorite, in some thin sections are well aligned parallel to the schistosity, and between such bands are fine mosaics of quartz and a little orthoclase. Among the phenocrystic minerals of the series, clearly of later origin than the groundmass, are staurolite, andalusite, ottrelite, biotite, chlorite, garnet, ilmenite, and magnetite. Zircon, graphite, and rutile are present locally. Small crystals of tourmaline, cutting the schistosity in all directions, are present in most of the thin sections. The occurrence of this mineral 10 miles or more from the nearest granitic outcrop possibly indicates the presence of a considerable body of granite beneath the Amargosa Range. The interbedded marbles are fine- to medium-grained rather dense rocks, of buff, pink, purple, gray, or white color. Much of the marble is finely laminated. The presence of clastic grains and small pebbles of quartz and of cross-bedding indicates that the original limestone was deposited in shallow water. Through metamorphism not only has the rock been thoroughly recrystallized and locally somewhat silicified, but muscovite has been developed on the parting planes, and calcite veins, cutting it in all directions, have been formed.

Interbedded with and sending short arms out into the schist at Poison Spring are thin discontinuous sheets of hornblende gneiss, composed of a fine mosaic of quartz and feldspar, with much fibrous greenish-black hornblende and in certain bands red garnet. Under the microscope the mosaic is seen to be composed of quartz, orthoclase, and plagioclase. In the mosaic are large skeletons of hornblende, garnet, zoisite, and titanite. Apatite and magnetite are present as accessory minerals. Chlorite is secondary to hornblende, sericite, or kaolin, and calcite to the feldspars, and zoisite to the mutual alteration product of hornblende and plagioclase. A sheet of hornblende schist cuts across the bedding planes of marble and schist at a low angle 200 yards west of the Chloride Cliff camp, near the head of a gulch. The sheet is over 200 feet thick and is at least one-fourth mile long. This schistose rock is composed largely of hornblende, with some quartz and feldspar. Red garnets which reach a maximum diameter of one-half inch are abundant in some portions of it and are also present in the adjacent sericite schist. The hornblende schist is composed of the following minerals, named in the order of their abundance: Hornblende, quartz, biotite, plagioclase (oligoclase in part), orthoclase, garnet, magnetite, and apatite. The rock has the form of a sheet injected in the Cambrian rocks. This schist and the gneiss above described, each of which is probably a mashed basic igneous rock, are the oldest igneous rocks known in the area surveyed. The hornblende rocks are older than the post-Jurassic granite, which is everywhere massive, and since they have suffered approximately the same metamorphism as the rocks which they inject they are probably of Paleozoic age.

The sedimentary rocks of this series were laid down in a shallow sea in which the conditions of deposition were constantly and rapidly changing. Fragmental material was carried into the sea even during the deposition of limestone, since clastic quartz grains are common in it.

The series is identical with that of Tucki Mountain, in the Panamint Range. Its age was not definitely determined, since unfortunately the contact with the Ordovician and Silurian rocks lies between two traverses made across the range. Lithologically it more closely resembles the Prospect Mountain quartzite (Cambrian) of the Specter Range than any other formation. The two are both quartzites, with shale and conglomeratic facies containing similar pebbles. Limestone was, however, not noted in the quartzite of the Specter Range. While tentatively considered Cambrian, these sedimentary rocks may in reality be of pre-Cambrian age. The severe metamorphism of the series indicates that the rocks have undergone folding not suffered by the Ordovician rocks farther north, and that they are hence of pre-Ordovician age.

Pogonip limestone.—The Pogonip limestone extends from Keane Springs northwestward to Grapevine Canyon. It also covers a large area north of Grapevine Springs and smaller areas in the vicinity of and north of the Staininger ranch, east of Cave Rock Spring, and 4 miles east of boundary post No. 94. In the large area north of Keane Spring from 2,000 to 3,000 feet of limestone is exposed. It is a fine- to medium-grained dense rock, most of it dark gray or black in color, though some beds are light gray. The laminæ are as a rule from one-sixteenth to one-fourth inch thick, while the bedding planes are from 4 inches to 40 feet apart, heavy bedding being rather characteristic. Calcite veinlets anastomose throughout the limestone mass, and in Titus Canyon areas of coarse white calcite blotch the limestone. A thin bed of white quartzite is interbedded with the limestone in the lower part of the series at Cave Rock Spring. Similar quartzite and black flint occur in the limestone north of Grapevine Springs.

The Pogonip limestone is rather fossiliferous, the fossils being of Ordovician age. From the limestone north of Grapevine Springs poorly preserved fossils were collected, which Mr. E. O. Ulrich identified as *Orthoceras olorus* and *O. perroti*, other *Orthoceras* fragments, and a fragment of a pelecypod probably of the genus *Clionychia*. These fossils indicate a middle Ordovician horizon. Mr. F. B. Weeks[a] collected Ordovician fossils from the main Paleozoic area, 5 miles southeast of the Staininger ranch, and Mr. G. K. Gilbert[b] collected fossils in Boundary Canyon which he considered early Silurian or Cambrian.

Eureka quartzite.—Overlying the Pogonip limestone near Boundary Canyon is about 800 feet of quartzite. It is well exposed at Daylight Spring and is a pink, rather pure quartz rock of medium grain. The bedding planes, which are rather massive, are emphasized by many fine laminæ varying slightly in color and in size of the constituent grains. Conglomeratic bands containing well-rounded pebbles one-half inch in diameter occur. Some of the pebbles are of quartzite, possibly derived from Cambrian rocks. Thin layers of black fine-grained argillaceous quartzite and of olive-green or brown slaty shales are also interbedded with the normal quartzite. This rock is correlated, with considerable confidence, with the Eureka quartzite (Ordovican).

Lone Mountain limestone.—Overlying the supposed Eureka quartzite in the vicinity of Keane, Daylight, and Willow springs is about 300 feet of limestone which resembles the Pogonip closely, although less distinctly bedded. This is probably the Lone Mountain limestone[c] of the Eureka section. The inlier 4 miles north of the Staininger ranch is composed of fine-grained dark-gray limestone, with interbedded black flint, white or pink quartzite, and limy shales. Imperfect silicified fossils, one of which Mr. E. O. Ulrich considers a late Silurian coral (genus *Cladopora*), were collected by the writer from this locality. Other small inliers in this vicinity may in realty be the Lone Mountain limestone rather than the Pogonip.

Siebert lake beds and contemporaneous deposits.—The rather large mass of later rhyolite and biotite latite to the southeast of Staininger's Ranch has between its flows layers of white or light-colored incoherent tuffaceous sandstone, which readily breaks down into sand. The section at this point is as follows:

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[a] Spurr, J. E., Bull. U. S. Geol. Survey No. 208, 1903, p. 188.

[b] Gilbert, G. K., U. S. Geog. Survey W. 100th Mer., vol. 3, 1875, pp. 34, 169, 181.

[c] Hague, Arnold, Mon. U. S. Geol. Survey, vol. 20, 1892, pp. 57–59.

Section southeast of Staininger's Ranch.

	Feet
Lava, largely biotite latite	375
Rhyolite flows and some tuffaceous sandstone	100
Tuffaceous sandstone and thin rhyolite flows	375
Rhyolite flows	75
Tuffaceous sandstone	225

Between the lava and the sediments are minor erosional gaps, but these are probably current erosional unconformities, and the series is approximately all of one age. Bedding planes from 2 inches to 20 feet apart are well developed at some places.

Locally the tuffaceous sandstone lies unconformably upon folded Pogonip limestone. It is closely similar to that of the Mount Jackson hills and, like it, is overlain by siliceous lavas. This formation is, without much doubt, the Siebert lake beds.

A number of small areas of conglomerate occur on the eastern slope of the Amargosa Range, east of boundary post No. 94, southeast of Daylight Spring and north of Willow Spring. The rocks, varying from loosely to rather strongly consolidated material, consist of conglomerates and arkoses with a little shale. They range in color from green to red, yellow, or brown. Bedding planes, which are from 1 inch to 2 feet apart, are well developed. The pebbles in the conglomerate, which are very well rounded and many of them highly polished, reach a maximum diameter of 4 inches. They are derived principally from the Paleozoic rocks near by, with here and there a pebble of fine- to medium-grained granite, and in the area east of boundary post No. 94 some of earlier rhyolite. These rocks appear to be the shore deposits of a lake in which waves swept with considerable force. Material was transported from considerable distances, since granite does not now outcrop in the vicinity. Since the conglomerate contains pebbles of rhyolite and none of basalt, the deposits are younger than the rhyolite (early Miocene) and older than the basalt (Pliocene-Pleistocene), and in consequence of middle or late Tertiary age, presumably Miocene. They are approximately contemporaneous with the lake in which the Siebert lake beds were deposited, and it is believed that they are shore deposits of that lake. The conglomeratic lake beds of the Funeral Mountains, south of the area mapped, are to be correlated with these conglomerates.

Older alluvium.—From a point 8 miles north of Surveyors Well to a point 3 miles north of Mesquite Spring the western flank of the Amargosa Range is formed of older alluvium, and the same formation covers a considerable area west of boundary post No. 85. This deposit consists of clays and bowlder beds similar to those of Death

Valley and the Panamint Range and, like them, is considered in part of Pliocene and in part of Pleistocene age.

Probably representing stream gravels contemporaneous with the older alluvium are small areas of conglomerates in Boundary Canyon and in the gulch in which Poison Spring is situated. In Boundary Canyon, near Hole in the Rock Spring, reddish conglomerate lies upon the eroded surface of the Paleozoic rocks, from which the bowlders have been derived. These bowlders reach a maximum diameter of 3 feet. The stream bed of the Poison Spring gulch is largely cut in calcite-cemented conglomerates. At the mouth of the gulch these beds are 40 feet above the stream, but 2 miles above Poison Spring they are at stream level, indicating that the present grade is steeper than that of the stream which deposited these gravels. Calcite veins, many of which are banded, fill joint fissures in the conglomerates. In a few places narrow seams of limonite indicate that some pyrite was deposited with the calcite.

IGNEOUS ROCKS.

In addition to the hornblende gneiss and schist already described (p. 163), the igneous rocks of the Amargosa Range include post-Jurassic granite, pre-Tertiary diorite porphyry, and several Tertiary lavas.

Granite porphyry.—Dikes of granite porphyry cut the Pogonip limestone 6 miles northwest of the Staininger ranch. The rock has a grayish-pink fine-grained groundmass, which is exceeded in bulk by the phenocrysts. Unstriated pinkish-gray feldspars, which reach a maximum length of one-fourth inch, are more abundant than small rounded quartz phenocrysts. Rarely a little chlorite stained by iron suggests the former presence of biotite. Under the microscope the groundmass appears as a microgranitic aggregate of quartz, orthoclase, and a little plagioclase. With the phenocrysts of orthoclase and quartz are some of biotite altered to chlorite and calcite and a few of plagioclase. This granite porphyry is probably one of the post-Jurassic granites.

Diorite porphyry.—Fragments of a greenish-gray much-altered igneous rock occur in the desert gravels on the eastern slope of the range west of Rose's Well, and dikes of this rock probably cut the Cambrian sediments. The rock is apparently the pre-Tertiary diorite porphyry.

Biotite andesite.—The oldest of the Tertiary lavas is a biotite andesite, which occurs in a number of small areas between Grapevine Canyon and Willow Spring, being particularly abundant near Mexican Camp. The biotite andesite is a dense lithoidal or semiglassy rock, which is gray, green, brick red, or purplish red, the last color evidently being due in many cases to alteration. Phenocrysts are usually somewhat subordinate in bulk to the groundmass. Biotite and lath-shaped feldspars, many of them considerably altered, are as a rule equally abundant. The feldspar phenocrysts are slightly larger than those of biotite, but they are nowhere over one-fourth inch long and are in most places much smaller. Flow lines are present in the groundmass and many of the phenocrysts show flow orientation. Much of the rock is vesicular. The vesicles reach a maximum length of 1½ inches and are more or less completely filled by chalcedony and chlorite. Hyalite, chalcedony, and quartz occur along joint planes.

One thin section shows under the microscope as a biotite andesite with a groundmass composed of plagioclase laths in a rather ill-defined gently birefringent substance. The phenocrysts include plagioclase, biotite rimmed by beads of magnitite, orthoclase, and magnetite. The small plagioclase phenocrysts are simple and the large ones complex aggregates. Zircon is a rare accessory mineral. Another thin section, although clearly from the same magma, is somewhat more acidic, having affinities with latite. Quartz and orthoclase are present in the microfelsitic groundmass and orthoclase phenocrysts are as abundant as those of plagioclase.

The biotite andesite occurs in flows which were eroded prior to the outflow of the earlier rhyolite. On the range crest 4 miles south of Wahguyhe Peak the rhyolite contains small fragments of andesite. The andesite is in consequence younger than rhyolite and is probably of late Eocene age. The more acidic facies of the rock are mineralogically rather like the monzonite porphyry of the Kawich Range, which is older than the earlier rhyolite of that range, but which is probably contemporaneous with the earlier rhyolite of the Amargosa Range. The andesite and monzonite porphyry are probably, in a broad way, contemporaneous.

Earlier rhyolite.—Rhyolite forms the crest and eastern slope of the Amargosa Range from Thorp's mill to a point 2 miles northwest of Willow Spring, and thence to a point 2½ miles southeast of Daylight Spring it forms the eastern slope of the range. East-southeast of this point several small rhyolite areas occur.

The rhyolite series comprises a considerable number of siliceous volcanic rocks, which lie in well-defined flow beds. The predominant facies is a lilac, gray, white, or pink rhyolite, with lithoidal groundmass and medium-sized phenocrysts of equal volume. Of the phenocrysts, colorless or slightly smoky quartz and glassy, unstriated feldspar are, as a rule, equally abundant, although the feldspar may predominate. Biotite phenocrysts are usually sparse and of smaller size. Other facies are gray glasses without phenocrysts, but with highly developed perlitic parting, and black glass, with feldspar and fewer quartz phenocrysts. Similar rocks from other ranges prove, on microscopic examination, to be latite, and the series probably includes latite and siliceous dacite in addition to rhyolite. Compact aphanitic red facies of rhyolite are also common, and in these flow banding, lithophysæ, and spherulites are well developed. The rhyolite of Shale Peak (elevation, 7,370 feet), 4 miles southeast of Wahguyhe Peak, is a faded brick-red rock banded with pink lines. Exfoliation breaks this rock, which is rather poor in phenocrysts, along the flow lines into numberless platy fragments, which caused the members of a United States Coast and Geodetic Survey party to give the peak its expressive name. Many angular inclusions of rhyolite of slightly different character occur in the lava, forming flow breccias. The rhyolite is in some places kaolinized and in others silicified. (See p. 47.) It is probable that much of the rhyolite that is now, through kaolinization, white or light gray in color, was formerly brick-red, since at certain places bleaching has occurred along joint fractures and irregular cracks, forming mottled fantastic patterns in reds and whites.

Beds and lenses of red, white, and greenish-white incoherent sandy rhyolitic tuffs, containing feldspar, quartz, and biotite crystals, are interbedded with the lavas. In these tuffs pebbles of rhyolite, which in rare instances reach a diameter of 1 foot, are abundant. All gradations exist between the normal igneous rock and these sediments deposited in small lakes or subaerial basins.

The earlier rhyolite of the Amargosa Range occurs in flows from 10 to 300 feet thick, superimposed one upon another, which impart to the eastern side of the range its varicolored banding. The thickness of the series is unknown, although it reaches at least 3,000 feet. The greater portion outflowed as lava, but at various times during the extrusion rhyolitic material was deposited in local sheets of water and at others dust from explosive eruptions formed subaerial accumulations. The vents from which the rhyolite flowed are probably situated near the crest line, but their position was not determined in the course of the present work. Where the rhyolite flows vary considerably in hardness the more resistant beds form benches and the softer beds are covered by talus, a method of weathering well developed on the eastern side of the north end of the range. Where vertical systems of joints are prominently developed, outcrops are bounded by vertical planes and rock pinnacles form. If the rhyolite flows are of approximately equal hardness and joints are not prominent, rounded bosses and smooth domelike hills result. Such forms are well seen near Shale Peak. Perhaps the most common topographic forms are cones, a mean between the pinnacles of the well-jointed rhyolite and the domelike hills of the more massive facies.

The earlier rhyolite lies upon the eroded surface of the Paleozoic rocks and the biotite andesite and near contacts contains numerous pebbles of these rocks. The later basalt lies upon the eroded surface of the rhyolite. This rhyolite is practically continuous with that of the Bullfrog Hills and is of similar lithologic character. It is roughly to be correlated with the earlier rhyolite of the Kawich, Belted, and Reveille ranges, probably of early Miocene age.

Earlier basalt.—Basalt fragments are locally contained in the rhyolite flow breccias, and at several places thin lenses of basalt, too small to show on the map, are interbedded with the rhyolite. The best example is at the Happy Hooligan mine, 12 miles south of west of Rhyolite. Mr. F. L. Ransome[a] states that recent mining development has here exposed a basalt bed from 25 to 50 feet thick between the rhyolite and the Pogonip limestone. The rhyolite of the Bullfrog Hills and the Kawich Range also contains minor flows of basalt, a fact further indicating the contemporaneity of the two rocks.

Later rhyolite and biotite latite.—To the southeast of the Staininger ranch is an area covering about 12 square miles of rhyolites and latites interbedded with the Siebert lake beds. The rhyolites are the older of these lavas and the latites the younger.

The rhyolites are semitransparent to opaque, glassy or semiglassy rocks, with few quartz, feldspar, and biotite phenocrysts. In color they range from light gray, through red, to black. Flow breccias are common. Perlitic parting, which causes the rock to disintegrate into pebble-like masses, is well developed in many of the flows. Flow folding, with overturned isoclinals, in places with horizontal axes, is not unusual. The spherulites, which are very abundant in some flows, making up at least one-third of the rock, are similar to those already described from the Mount Jackson hills (p. 67). In some cases large spherulites, rudely globular and from 3 inches to 1 foot in diameter, inclose smaller ones. The large spherulites are cut by horizontal flow lines, while the smaller have the typical radiate structure. Lithophysæ also occur.

The latites are white semipumiceous rocks with myriad bronze-brown hexagonal plates of mica and less conspicuous phenocrysts of feldspar. In some instances the biotite plates have an excellent orientation in the place of flow and the rock breaks into platy masses along the flow banding. A single thin section examined under the microscope showed the rock to be a biotite latite, with groundmass of a vesicular colorless glass. The phenocrysts exceed the groundmass in bulk, and orthoclase and biotite are more abundant than plagioclase. Apatite is present as an accessory mineral.

The later rhyolite is similar lithologically to the rhyolite associated with the Siebert lake beds of the Mount Jackson hills, and the two series are probably approximately contemporaneous. In the upper portion of the series a few basalt flows are apparently interbedded with the rhyolite. At another place the basalt clearly cuts the Siebert lake beds and the rhyolite. (See p. 171.) This shows that while toward the end of the period of rhyolite extrusion some basalt probably outflowed, for the most part the basalt is younger. The rhyolite and latite are probably of late Miocene and early Pliocene age.

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[a] Oral communication.

Later basalt.—Basalt is the youngest of the igneous rocks. Its flows cover a considerable area at the north end of the range, and a number of smaller areas occur on either side of Grapevine Canyon. A dike of basalt 4 feet thick cuts the younger rhyolite and Siebert lake beds 2 miles north of the Staininger ranch. This was probably one of the vents through which the lava outflowed, while a small, red, conical hill to the south of the Staininger ranch–Thorp road, 5 miles from the ranch, appears from a distance to be a volcanic cone. The two small buttes in Sarcobatus Flat, north and northeast of Currie Well, seen only from a distance, are probably basalt. Remnants of flows cap rhyolite hills southeast of Daylight Spring, and at one locality a dike of basalt cuts the Pogonip limestone. This dike may be the ancient vent from which the basalt in this vicinity flowed. The basalt of the dike is reddish brown in color and much altered, but on microscopic examination appears to have been originally an olivine basalt. The basalt from the flows in the vicinity is black, vesicular, and without prominent phenocrysts. The basalt of Grapevine Canyon is for the most part black and dense, although basal portions of the flows (in many places flow breccias) are vesicular and red. The more vesicular rocks are locally covered by a layer of basalt banded horizontally by flow lines, and this in turn by more massive beds which show spheroidal weathering. Phenocrysts, while usually small, are abundant in many outcrops and include glassy laths of plagioclase and rounded grains of olivine, either fresh and glassy or iron stained. Granular calcite, probably derived from the alteration of the basalt, fills vesicles in the basalt and veins cutting it. A thin section cut from basalt from the low mesas 4 miles east-northeast of the Staininger ranch proves to be a quartz-bearing olivine basalt with holocrystalline groundmass. The quartz is deeply embayed and surrounded by a corona of augite columns of the groundmass.

The basalt from the south end of the Amargosa Range overlies the Siebert lake-bed conglomerates, and from its lithologic character is considered to be one of the Pliocene-Pleistocene basalts. The basalt in the vicinity of Grapevine Canyon is probably in part contemporaneous with the upper part of the later rhyolite and Siebert lake beds, but is for the most part younger and of late Pliocene or early Pleistocene age.

STRUCTURE.

The Amargosa Range has been subjected to two main periods of folding and uplift, the earlier in pre-Tertiary and presumably post-Jurassic time, the later probably in late Miocene time, after the deposition of the Siebert lake beds. In the northern part of the range this later folding was somewhat earlier than in the southern part and appears to have succeeded the outflow of the earlier rhyolite and preceded the deposition of the Siebert lake beds. North of Wahguyhe Peak the Paleozoic rocks and the earlier rhyolite are so folded together that the differentiation of the two periods of folding is difficult. Even here, however, the Paleozoic rocks are more profoundly folded. The earlier folding was accompanied by reversed faulting and probably in the last stages by normal faulting; the later folding was accompanied by normal faulting.

The major direction of the early folds was parallel to the trend of the range, but accompanying them are cross folds, which west of Grapevine Peak equal in importance and south of Indian Pass predominate over the northwest-southeast folds. In the vicinity of Grapevine Peak these cross folds were intensified by later folding. In the central portion of the range there is an anticlinorium with northwest-southeast axis, composed of two main anticlines with a syncline between. The syncline at Keane Spring is comparatively narrow; at Boundary Canyon it is broader and more open; and in the canyon in which Tule Spring is situated it is represented by two minor synclines and an intervening anticline. At Chloride Cliff the syncline is broken by a normal fault. Many of the minor folds are closely appressed isoclinals or fan folds, which in some instances have horizontal axes. The passage from isoclinal folds to reverse faults is by no means unusual. South of Indian Pass the structure is that of an anticlinorium with northeast-southwest axis, of which the long northwest limb dips rather gently to the southeast, while the shorter southeast limb dips somewhat more steeply to the northwest. Superimposed upon the main folds are minor folds, many of which are rather steep. The Pogonip limestone north of Grapevine Springs is folded into a gentle arch with east-west axis.

Before the later folding was inaugurated the range was worn down to an inconspicuous ridge, and the eastern slope and the whole range south of the area mapped formed the bottom of the Miocene lake. It is to the later folding and succeeding minor uplifts that the range owes its height. South of Daylight Spring the rhyolites dip at angles of 20° to 40° away from the range, while the Siebert lake conglomerates in this vicinity have a dip away from the range which in some instances reaches 70°. North of Daylight Spring the earlier rhyolite is folded into a synclinorium whose axis strikes N. 70° E., with its trough situated about 4 miles north of Grapevine Peak. Normal strike faults having the same strike are common in the vicinity of Thorp's mill and form numerous fault scarps. The Siebert lake beds south of the Staininger ranch have been flexed and are broken by small normal faults of north-south strike.

Unimportant folding and faulting are recorded in the basalt and older alluvium areas. The basalt below the Staininger ranch dips toward Death Valley and has apparently been tilted westward along a north-south axis. Normal faults of 4 to 5 feet displacement, usually with north-south trend, cut the basalt in the vicinity of Grapevine Canyon. The older alluvium at Hole in the Rock Spring for the most part dips toward Death Valley, although northeasterly dips here and there indicate that since the deposition of the conglomerate the range has not only been uplifted, but also somewhat folded.

ECONOMIC GEOLOGY.

Active mining operations are being caried on at three points in the Amargosa Range within the area mapped—at the Happy Hooligan mine, at Chloride Cliff, and at Lee's Camp.

HAPPY HOOLIGAN MINE.

The Happy Hooligan mine is situated at the eastern base of the Grapevine Mountains, 9 miles northwest of Bullfrog. A number of test pits have been sunk at the contact of the eroded surface of the Pogonip limestone, with its interbedded quartzite and the Tertiary lava flows. The predominant lava is a kaolinized rhyolite, from which the feldspar phenocrysts have been largely removed by weathering. This is underlain by a flow of basalt which rests upon the limestone. At the contact with the limestone the basalt is reddened by hematite and altered to a greasy substance, which pans fine free gold, as does the limestone when decomposed. Gold values also occur where the lava comes in contact with the quartzite. The contact has been traced several hundred feet and values are reported from all the test pits. The ore is free milling, and no sulphides were observed. It is said to run $40 in gold per ton, the values appearing to be closely associated with limonite and hematite. Several springs are situated near the mine and fuel can be obtained within 6 miles. The road to Bullfrog is rather heavy.

CHLORIDE CLIFF.

Chloride Cliff is situated in Inyo County, Cal., on the crest of the Amargosa Range, 15 miles south of Bullfrog. At this point the Cambrian limestone strikes N. 15° W. and dips 30° E. A steeply inclined fault trending N. 50° W. cuts the limestone. The limestone along the fault is silicified and in it are disseminated galena and some chalcopyrite. The secondary ore is a porous yellowish lead carbonate with some malachite stains. The surface outcroppings are heavily stained by limonite. At another place a 4-foot vein of quartz lies between the gently dipping hornblende schist and the sericite schist and altered limestone above it. The quartz is free milling and heavily iron stained, and the crushed portions have been recemented by limonite. The writer traced the vein 200 feet, but it extends much farther. It is reported that one sampling across the vein gave values in gold averaging $1,500 per ton. At a third prospect a reversed fault cuts the schist member of the series, which here strikes N. 60° W. and dips 15° NE. A quartz vein 2 to 3 feet wide occupies the fissure. The quartz is stained by limonite, and pyrite is the only original sulphide seen. Small nodules of native copper are, in rare instances, associated with the limonite stains. The ore is said to assay from $13 to $500 per ton in free gold. The values are associated with limonite.

The prospects at Chloride Cliff are either fissure fillings or deposits along contacts. In some cases the quartz and accompanying sulphides probably filled open fissures; in others the limestone was metasomatically replaced. There is a distinct tendency for galena to be the predominant sulphide in limestone, and pyrite in the other country rocks. Since the deposition of the quartz the veins have been crushed and surface waters have produced from the original sulphides native gold, copper, cerussite, malachite, and limonite. The deposits are structurally similar to those which hold their values well with depth, and if surface enrichment has not been out of all proportion to the original sulphide values, further development is well justified.

Water is at present packed on burros from Keane Spring, 4 miles distant. Wood suitable for fuel occurs on the Amargosa Range, 10 miles north of the prospects, but at present must be teamed by way of Bullfrog. A fair road connects the prospects with Bullfrog, the shipping and supply point.

Ores from a number of mines in the Cambrian rocks in the vicinity of Chloride Cliff were examined, but the mines themselves were not visited. At the Keane Wonder mine a blanket vein of quartz, dipping gently westward, is said to lie along the bedding planes of the Cambrian rocks. The gold ore is quartz heavily stained by limonite and is said to be free-milling. The Trio mine, in the next gulch south of the Keane Wonder, is said also to be on a quartz vein in the Cambrian rocks. The ore is a limonite-stained quartz containing chalcopyrite and galena and some cerussite. Free gold is reported to occur in schist and limestone along a fault fissure down the gulch from Keane Spring. The ore of this deposit closely resembles that from the metasomatic replacement deposits of Chloride Cliff. The

Bismuth mine is situated on the road to Bullfrog, somewhat below the Chloride Cliff mine. The quartz, which is heavily stained by limonite, contains finely granular galena. The presence of some malachite probably indicates the former presence of chalcopyrite with the pyrite and galena.

LEE'S CAMP.

Lee's Camp is situated in the Cambrian rocks, 10 miles southwest of Rose's Well. The camp was not visited by the writer, but strong veins of quartz are said to exist there. The ore, which is said to mill free gold, is quartz and either dolomite or siderite, each heavily stained by limonite.

AREAS FAVORABLE FOR PROSPECTING.

Quartz veins are common in the metamorphosed Cambrian sedimentary rocks. They occupy joint and bedding planes and fault fissures, and in the latter case may contain angular fragments of the Cambrian rocks. In size they vary from mere stringers to veins 6 feet or more across, which can be traced for hundreds of yards. In the vicinity of Poison Spring these are particularly strong, and over restricted areas make up almost one-third of the rock. The quartz in most instances is white and semitransparent and appears barren. In others it has been faulted and brecciated and is stained by limonite, while pyrite and specular hematite are disseminated in it here and there. The mines of Echo Canyon, to the south of the area surveyed, are reported to be situated on similar quartz veins. Pyrite and hematite also occur in quartz veins on the small Cambrian hills to the northwest of the Big Dune, and these minerals and malachite are found in the quartz veins of the big Cambrian inlier to the southwest of the Big Dune.

In the Pogonip limestone of the central and northern portion of the Amargosa Range quartz veins are of minor importance. The veins, some of which contain pyrite and specular hematite, appear to be comparatively small. About 6 miles south of the Staininger ranch prospectors sunk a shaft 10 feet deep on a quartz vein stained with malachite. At this depth the vein divided into several stringers and the shaft was abandoned. The ore carried low gold and silver values. With the change of the country rock from the siliceous deposits of the Cambrian area to the calcareous rocks of the Silurian and Ordovician, calcite veins, probably in part contemporaneous with the quartz veins, become predominant. These are extremely abundant, but as a rule are less persistent and less mineralized than the quartz veins in the Cambrian. At Titus Canyon the calcite veins are of two ages. The older are formed of white crystalline calcite, much of which is very coarsely granular. The younger veins, of banded yellow or brown calcite, are still forming. River bowlders are here and there inclosed in these veins, and stalactitic calcite hangs from them in some canyon walls. The bands are either parallel to the walls or at right angles to them, while in certain places the borders of the veins are vertically banded and the centers horizontally banded. Many of the later veins fault the older.

Areas of silicified and kaolinized rhyolite in the Amargosa Range are shown on the map (fig. 4, p. 43). The rhyolite 8 miles southeast of Daylight Spring has been silicified, and small quartz veins cut it. The area has been located, but no information is at hand as to the value of the ore. Silicified rhyolite, with many small quartz veins, outcrops at several places east of Mexican Camp and 1 mile north of McDonald Spring. At the latter locality small quartz veins also occur in the biotite andesite. The quartz in this portion of the range is largely white or gray and compact. At Currie Well bowlders of silicified rhyolite, said to pan gold, occur as float, but the original position of the rock is not known. Silicified rhyolite stained by the yellow basic ferric-alkali sulphate (?) already mentioned (p. 50) covers a considerable area to the south of Grapevine Canyon. This rhyolite is doubtless worthy of careful prospecting.

BULLFROG HILLS.[a]

TOPOGRAPHY AND GEOGRAPHY.

The Bullfrog Hills lie west of Oasis Valley, between the Amargosa Desert and Sarcobatus Flat. They form a spur of the Amargosa Range and have an east-west crest line, from which an eroded mesa extends northward and rather sharp ridges stretch out to the south. The highest peak in the hills reaches an elevation of 6,035 feet. The Bullfrog Hills are bare of timber and are only sparsely covered with desert shrubs and cacti. The towns in these hills obtain water from Amargosa River (see p. 18) and from a number of springs in Oasis Valley and in the hills themselves. Among the latter may be mentioned Indian (30,000 to 40,000 gallons per day), Crystal, and Mud springs. Hicks Hot Springs, in Oasis Valley, have already been described (p. 20).

GENERAL GEOLOGY.

The formations exposed in the Bullfrog Hills include the following, the oldest being named first: Pre-Silurian schist, Eureka quartzite, Lone Mountain limestone, post-Jurassic pegmatite, pre-

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[a] The geology and ore deposits of the Bullfrog district will be described in detail by Messrs. F. L. Ransome, W. H. Emmons, and G. H. Garrey in a forthcoming Professional Paper, and the geology of the area shown on the Bullfrog special sheet has been generalized from their map. The description here given refers more particularly to the area outside that covered by the special map.

Tertiary diorite porphyry, andesite, rhyolite, earlier basalt contemporaneous with rhyolite, Siebert lake beds(?), and later basalt.

SEDIMENTARY ROCKS.

Pre-Silurian schist.—Three miles west of Bullfrog is a low ridge of post-Jurassic pegmatite containing a vast number of schist inclusions. The rocks are present in practically equal amounts, and the area could as well be described as an area of schist intensely injected by pegmatite. The pegmatite, however, is more resistant to erosion and hence gives its white color to the low rounded ridge.

The schist varies from a finely foliated biotite schist to an "eye" schist, containing many lenses of pegmatitic feldspar from one-sixteenth inch to 2 inches long. These eyes are elongated parallel to the schistosity, the shortest diameter usually being one-fourth the length of the longest. Some of the schist is composed of minute scales of biotite of common orientation, while other portions also contain quartz, a little feldspar, and the large feldspar lenses already mentioned. The planes of schistosity dip at considerable angles, but are rarely minutely crenulated. A single thin section of the "eye" schist under the microscope proves to be a schist in which shreds of biotite and a little muscovite are arranged in folia. Between these is a fine-grained mosaic of orthoclase and quartz, with here and there a partial crystal of apatite or zircon. The pegmatitic "eyes," which are usually acidic plagioclase and in only a few cases quartz or orthoclase, are closely encircled by the biotite films.

The schists are presumably metamorphosed sedimentary rocks, but they may possibly be mashed igneous rocks. Mr. G. H. Garrey,[a] who examined the relations between the schist and the Pogonip limestone on the western border of the Bullfrog special area, states that the contact between the two rocks is not exposed, but that outcrops of limestone adjacent to the schist are comparatively unmetamorphosed and that the schist in consequence is presumably pre-Silurian. Lithologically this rock resembles Cambrian schists near Tokop, and although possibly of pre-Cambrian age it is tentatively correlated with the Cambrian.

Eureka quartzite.—A hillock rising from the rhyolite to the southeast of the limestone last described and a hill 2 miles south of Indian ranch are formed of quartzite interbedded with shale. Fragments of similar shale are included in Tertiary rhyolite 3½ miles northeast of Bullfrog. The Eureka quartzite of Bare Mountain extends across Amargosa River northwest of Gold Center. The quartzite of the hills first mentioned is gray, pink, or white in color, and of fine to medium grain. It appears to be a practically pure quartzose rock, many portions of which are finely laminated. Associated with it are minor bands of brown, greenish, or purplish-gray shale, the laminæ of which are in places paper thin. The quartzite apparently underlies the limestone south of Indian ranch and lithologically resembles the Eureka quartzite (Ordovician).

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[a] Oral communication.

Lone Mountain limestone.—Small bodies of limestone, in part, at least, of Silurian age, protrude from the Tertiary lavas and Recent gravels at four points—3 miles west of Bullfrog, three-fourths mile southwest of the Gold Bar mine, and 1½ miles south and 2½ miles southeast of Indian ranch. The limestone is dark gray, dense, and of medium grain. Finer grained facies closely resemble lithographic limestone. Interbedded with the normal type are layers of intraformational conglomerate. Thin seams of calcite locally cut the limestone in all directions. The limestone 1½ miles south of Indian ranch clearly overlies a quartzite which is probably the Eureka quartzite; if so this is the Lone Mountain limestone. Moreover, Mr. G. H. Garrey collected from the limestone inlier 4 miles northwest of Bullfrog a number of fossils which Mr. E. O. Ulrich states are of Silurian age.

Siebert lake beds.—One mile north of Crystal Spring is a small outcrop of an arkose conglomerate. The well-rounded pebbles, which reach a diameter of 1 foot, consist of quartzite, jasperoid, limestone, and medium-grained biotite granite. The first three are derived from Paleozoic rocks, while the granite resembles many post-Jurassic granites. The conglomerate is lithologically similar to the more conglomeratic of the Siebert lake beds of the Amargosa Range, and may well be contemporaneous with it. If such is the case the shore line of the lake must have been near Bullfrog. The relative ages of the rhyolite and the lake beds are unknown.

Older alluvium.—On the northeastern face of the Bullfrog Hills and across Amargosa River to the east are hills and terraces dissected by the present streams. These hills and terraces are formed of detrital material similar to that now being deposited in stream beds and on the alluvial slopes. The deposits were made while Amargosa River was at a higher level and presumably are alluvial slope deposits of the older alluvium. Basalt bowlders (presumably of Pliocene-Pleistocene age) are contained in the upper portion of the beds.

IGNEOUS ROCKS.

Post-Jurassic pegmatite and alaskite.—Pegmatite with alaskite occurs with the pre-Silurian schist west of Bullfrog and dikes of pegmatite cut the Eureka quartzite near Gold Center. (See p. 155.) West of Bullfrog the pegmatite grades into alaskite, but the former rock is predominant. The most widely distributed facies of pegmatite is formed of white feldspar, less muscovite, still less smoky quartz, and a little pyrite. The largest feldspar individuals reach a diameter of 4 inches, while muscovite is in aggregates of plates from one-fourth to 1 inch across. Quartz veins of pegmatitic origin are also present and similar veins, probably of the same origin, cut the more feldspathic pegmatite. From this it is probable that a rock of granitic composition separated from the magma and at a later period a more quartzose rock was deposited from the residual liquid in fractures in the older pegmatite. Lens-like veins of practically pure white feldspar grade on the one hand into normal pegmatite, and on the other into the eyelike areas of the schist already mentioned.

The associated alaskite is a white, medium-grained rock composed of quartz and feldspar, with muscovite and a little altered biotite. The quartz and orthoclase grains are micropegmatitically intergrown along their borders and the biotite shreds are largely chloritized. Accessory minerals are not abundant, but include apatite, zircon, and magnetite, and apparently tourmaline. In the hand specimen the rock is considerably mashed and the microscope shows phenomena of granulation and recrystallization, including the deposition of muscovite, derived from feldspar, in fractures.

The pegmatite and alaskite inject the schist bed by bed, although in rare instances the planes of schistosity are crossed. The wider pegmatitic bands are 100 or more feet thick, while the thinner pegmatitic layers are but one-fourth inch wide, and many of them are separated only by an equal thickness of schist. The pegmatite cuts schists probably of pre-Silurian age and is older than the unmashed rhyolite of Tertiary age. On lithologic grounds its age is provisionally believed to be post-Jurassic and pre-Tertiary.

Pre-Tertiary diorite porphyry.—A few narrow dikes of diorite porphyry cut the pegmatite and schist 3 miles west of Bullfrog. The diorite porphyry is a dark grayish-green rock speckled with tiny white areas, and is evidently composed predominantly of a ferromagnesian mineral and feldspar. The rock has a medium-grained microgranitic groundmass of plagioclase, orthoclase, and some quartz. Columns of brown hornblende are very numerous, while larger phenocrysts of sericitized plagioclase are fewer. The accessory minerals, titanite, apatite, and magnetite, are very abundant. Epidote and chlorite are developed from hornblende or from hornblende and plagioclase. This rock is, without much doubt, to be correlated with the pre-Tertiary diorite porphyry widely distributed in the mountains on the western border of the area surveyed. (See p. 31.)

Biotite andesite.—A hill 2 miles northwest of Howell ranch and a small knob rising from the older alluvium three-fourths of a mile south of Indian ranch are of biotite andesite. This is a dense, flinty or lithoidal rock of medium, pinkish, or purplish gray color. Black glassy facies are less common. The small phenocrysts, feldspar laths, with slightly fewer black mica plates are subordinate to the groundmass in bulk. The feldspars are usually altered, but in some instances they are glassy and twinning striations are visible. From the bedded disposition of the various textural facies and the flow orientation, visible in many of the phenocrysts, the biotite andesite is probably a flow considerably eroded and masked by coverings of later formations. The groundmass under the microscope is seen to consist of a felt of plagioclase laths in a somewhat devitrified glass (hyalopilitic). Besides the simple laths of plagioclase, usually showing Carlsbad twinning, and the slightly bleached biotites, a rare orthoclase phenocryst is present, while certain ill-defined pseudomorphs, largely of serpentine, have the crystal outlines of hornblende. Ilmenite and apatite are present as accessory minerals.

On the west side of the hill northwest of Howell ranch much-altered pebbles and fragments of andesite are included in a tuffaceous member of the rhyolite series, and between the outflows of the two lavas there was apparently an erosion interval. The andesite is probably of late Eocene age, and is similar to and probably contemporaneous with the biotite andesite of the Amargosa Range.

Rhyolite.—The predominant formation of the Bullfrog Hills is a series of rhyolite flows. The most widely distributed facies is a lithoidal rhyolite of gray, pink, or purple color. The medium-sized phenocrysts, which usually exceed the groundmass in bulk, consist of glassy unstriated feldspar, slightly smoky quartz, and in many places biotite. Hornblende is also locally present. Less widely distributed types include aphanitic rocks with varicolored flow banding, resembling slaty shales; brown or greenish glasses, with or without phenocrysts, and gray glasses with perlitic parting well developed. Interbedded with the other members of the rhyolite series are rhyolitic sandstones and conglomerates, while Messrs. Ransome, Emmons, and Garrey found a thin limestone lens in the series. Through metamorphism, kaolinized and silicified facies arise. (See p. 47.)

The rhyolite is a series of igneous flows, with minor intercalated beds of sedimentary rocks, in part deposited under water and in part subaerially. Where the flows are thick the rhyolite in places weathers into bosses and low domes, but for the most part the varying resistances of the different flows to erosion give a bench and cliff character to the topography.

This rhyolite, which contains fragments of Paleozoic rocks and biotite andesite, on lithologic and structural grounds is correlated with the earlier rhyolite of the Amargosa and Kawich ranges. It is probably of early Miocene age.

Earlier basalt.—Interbedded with the rhyolite series in the Bullfrog district are several thin flows of basalt, and the latest of these is also found in the surrounding hills near the boundary of the special area. Dacite usually lies on the basalt and is evidently a later flow of a practically continuous period of extrusion. The basalt is a dark-gray or blue-black dense rock containing numerous laths of glassy striated feldspar and here and there a suggestion of an olivine or pyroxene phenocryst. Vesicular facies are common, and with the introduction of vesicles much of the rock takes on a red tinge. A single thin section examined proved to be an olivine basalt, with plagioclase, augite, and olivine phenocrysts in a groundmass composed of glass and tiny crystals of plagioclase, pyroxene, and iron ore (hyalopilitic).

Dacite is well exposed 1 mile southwest of Indian Spring. It is a purplish-gray rock, with dense groundmass and abundant phenocrysts, including glassy striated feldspar, black mica, and quartz. The feldspars very in size from one-sixteenth to 1 inch, the larger ones usually showing well-developed zonal growth. The quartz crystals reach a maximum diameter of one-fourth inch. Under the microscope the groundmass is seen to be a glass containing many tiny plagioclase laths (hyalopilitic). Besides the phenocrysts already mentioned, augite is present, while aggregates of heavily iron-stained serpentine may possibly be altered olivine.

Later basalt.—Large areas of later basalt cap the rhyolite in the northern portion of the hills and pass into northeastward-dipping mesas, which extend toward Pahute Mesa. The basalt, which is a dense black rock, locally vesicular, lies upon the eroded surface of the early Miocene rhyolite. It is similar lithologically to and appears to be an extension of the Pahute mesa basalt, and is, in consequence, probably of late Pliocene age.

STRUCTURE.

The isolated inliers of Ordovician-Silurian rocks are gently folded and somewhat faulted. Upon the major folds minor flexures, in some cases overturned isoclinals, are superimposed. The folding of the Paleozoic rocks probably occurred largely prior to Tertiary time, although the supposed Siebert lake beds appear to be conformable in dip with the Lone Mountain limestone. The rhyolite throughout the Bullfrog Hills is a mosaic intersected by numerous normal faults. These faults have been worked out in detail by Messrs. Emmons and Garrey in the area covered by the Bullfrog special map. The work carried on under the direction of Mr. F. L. Ransome shows that the predominant faults trend northeast, while a second set trends north and south. The later basalt is slightly tilted to the northeast.

ECONOMIC GEOLOGY.

The ore deposits of Bullfrog have recently been described by Ransome.[a] He shows that the ore occurs in and along fault fissures in silicified or kaolinized rhyolite. Silicification and kaolinization have been important processes of metamorphism throughout the Bullfrog Hills. The areas outside of the region shown on the Bullfrog special map so altered are delineated in fig. 4 (p. 43). Both the rhyolite and the andesite of the two domelike hills northwest of Howell ranch are silicified, and in addition seams of chalcedonic quartz fill solution cavities and fault and joint fractures. Other areas of silicified rhyolite are situated northwest of Crystal Spring, west of Indian Springs, and 4 miles south of east of Currie Well.

GOLD MOUNTAIN RIDGE AND THE HILLS TO THE NORTH OF GRAPEVINE CANYON.

TOPOGRAPHY AND GEOGRAPHY.

Gold Mountain, with an elevation of 8,145 feet, is situated on a ridge which parallels Slate Ridge. North of Tokop the two ridges are connected by low hills. The Gold Mountain ridge lies to the south of Oriental Wash and to the east of Death Valley. In the vicinity of Gold Mountain the ridge is rugged and steep, being formed of sharp peaks and V-shaped valleys. Strikingly distinct from the other summits is the basalt-capped butte northeast of Old Camp. A number of northeast-southwest ridges northwest of Grapevine Canyon are joined to Gold Mountain on the south or are isolated in the desert gravels near by. These ridges, which parallel the trend of the Gold Mountain ridge, are here included in its description. On the other hand, the mountain front north of Grapevine Canyon, northeast of Death Valley, and southwest of the California-Nevada line is structurally an extension of the Amargosa Range.

The distributive drainage characteristic of arid regions is well exemplified in these hills. Fragmental material from the Gold Mountain ridge near the Rattlesnake mine has reached lower levels by three distinct channels. A portion of the gravels moved to the southeast and found lodgment either around the playa in Grapevine Canyon or was washed out into Sarcobatus Flat near Thorp's mill. A second portion traveled south 4 miles, north of east 2 miles, and then south around the hill at the junction of the county line and parallel 37° 15′. The material eventually mingled with that which took the more direct route already described. A third portion did not swing around the hill just mentioned, but continued north of east into Sarcobatus Flat. Probably at any one time but a single channel was used, but in comparatively recent times all three have been used.

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[a] Ransome, F. L., Bull. U. S. Geol. Survey No. 303 (in press).

Juniper and piñon cover the crest of the Gold Mountain ridge, the timber line being on the 6,200-foot contour on the south and on the 6,700-foot contour on the north side of the ridge. Yucca groves are sporadically distributed over the rhyolite and basalt flows to the south of the main ridge, while a fair growth of grass covers Gold Mountain and the surrounding hills. The main ridge on which Gold Mountain is situated is well watered. Tunnels and wells in the vicinity of Old Camp strike water at depths varying from 50 to 75 feet. The water in some cases appears to flow from crevices in granite and in others to seep from the overlying soil. Two wells located in Cambrian sedimentary rocks 1 mile east and northeast of Tokop are about 20 feet deep. The water is said to come from rock crevices. The water of Sand Spring, west of the boundary of the area here discussed, in Death Valley, is rather strongly impregnated with sulphur, but is nevertheless usable.

GENERAL GEOLOGY.

The formations exposed in the Gold Mountain ridge and the adjacent hills, from the base up, are as follows: Cambrian sedimentary rocks, quartz-monzonite porphyry, post-Jurassic granite, pre-Tertiary diorite porphyry, rhyolite, and basalt.

SEDIMENTARY ROCKS.

Cambrian.—Cambrian rocks form the rugged ridge northeast of Tokop and the western front of the ridge facing Death Valley. A thin band of Cambrian rocks rims the southern border of the granite batholith which forms the central portion of the main ridge. These narrow Cambrian masses between the granite and the Tertiary rhyolite are due to the fact that resistance to late Mesozoic and early Tertiary erosion was greater in the granite and the adjacent metamorphosed Cambrian rocks than in the unmetamorphosed Cambrian rocks. Large inclusions of Cambrian schist and metamorphosed limestone are sporadically distributed in the granite, while small fragments are widely distributed in both granite and rhyolite.

The Cambrian rocks of the Gold Mountain ridge include interbedded metamorphosed shales and impure limestones and calcareous sediments. The amount of metamorphism suffered by these rocks decreases with increase of distance from the granite batholith. Argillaceous rocks are widely distributed, although they do not appear to be present at the extreme west end of the range. They include fine-grained, well-banded slates of black to light-gray color and biotite schists both with and without knotlike aggregates of biotite.

Limestone and calcareous sediments are represented by white and gray marbles of medium to coarse grain and by lime-silicate rocks in which brown garnet, vesuvianite, epidote, tremolite, chlorite, and serpentine are developed. These rocks are usually well banded. One of the striking types is composed of layers of brown garnet and white quartz, alternating with fine-grained bands of quartz, epidote, and other silicate minerals in which large crystals of brown garnet are locally embedded. Garnet also occurs in veins cutting the rocks, indicating a second recrystallization of that mineral. A single specimen of the banded rock examined under the microscope proved to be an uneven-grained, banded rock. The contemporaneous constituents of recrystallization include slightly brownish garnets, quartz, epidote, zoisite, tremolite, calcite, orthoclase, and plagioclase (oligoclase and andesine), in places showing Carlsbad twinning. Apatite and titanite are present as accessories and sericite and chlorite as secondary minerals derived from the feldspars. At the west end of the Gold Mountain ridge bands and lenses of brown garnet rock up to 30 feet in thickness are interbedded with white and canary-yellow marble. Crystals of garnet also occur in the numerous interstices of the weathered surface.

These metamorphosed sedimentary rocks are similar to those of Slate Ridge, which grade into less metamorphosed facies, probably of Lower Cambrian age.

IGNEOUS ROCKS.

Quartz-monzonite porphyry.—The granite, particularly near Old Camp, contains inclusions up to 1 foot in diameter of a fine-grained, medium-gray igneous rock, formed of biotite and white feldspar, in which are rather sparse phenocrysts of pink orthoclase reaching a maximum length of one-half inch, smoky quartz grains one-fourth inch in diameter, and smaller biotite plates. Under the microscope the groundmass is seen to be hypidiomorphic granular and to consist of grains of orthoclase and partial crystals of plagioclase (oligoclase) and biotite, with a little quartz. Magnetite, titanite, zircon, and apatite are abundant accessory minerals. The phenocrysts are orthoclase, much of it zonally grown, quartz, biotite, and more rarely plagioclase. Similar inclusions occur in a number of the post-Jurassic granular rocks in other portions of the area, but beyond the fact that the quartz-monzonite porphyry is older than the granite, its age is unknown.

Post-Jurassic granite.—The central portion of the Gold Mountain ridge is a mass of granite which prior to the formation of Oriental Wash was probably connected with the granite batholith at the west end of Slate Ridge. The smaller area of granite 8 miles west of Gold Mountain was also perhaps at one time connected with the Slate Ridge batholith. Dikes and apophyses extend from the main mass into the Cambrian rocks.

The predominant type in the vicinity of Gold Mountain is an uneven-grained, coarse, pink biotite granite. The constituents are pink feldspar, locally in good crystals one-half inch long which show Carlsbad twinning, slightly smoky quartz, and black biotite. Microscopic examination shows this granite to be formed of quartz, microcline, microperthitic orthoclase (in some specimens), oligoclase, biotite, and magnetite. Quartz shows strong undulose extinction. Sericite and kaolin are alteration products of the feldspars. The granite at the west end of the ridge is more variable in character, the most abundant type being a fine- to medium-grained gray biotite granite. This is composed of quartz, orthoclase, plagioclase, and biotite, with titanite, magnetite, muscovite, zircon, and apatite as accessory minerals. Plagioclase (oligoclase) occurs in rude laths. The coarse pink variety of Gold Mountain is also present, and it grades into a gray granite porphyry, with fine-grained groundmass of quartz, biotite, and feldspar. The phenocrysts, which reach a maximum length of one-half inch, are tabular gray feldspars rimmed by white bands, some of them Carlsbad twinned; rounded, strongly smoky quartz, and hexagonal biotite. The microscope shows that this granite porphyry has a hypidiomorphic groundmass, composed of orthoclase, quartz, biotite, and plagioclase, with magnetite, apatite, and titanite as accessory minerals. Quartz in this granite is notably variable, being abundant in some outcrops and inconspicuous in others. With decrease in quartz the normal granite porphyry grades into a quartz-poor hornblende-bearing porphyry in which some pink feldspar phenocrysts are 1 inch long. Under the microscope this proves to be a quartz-monzonite porphyry, with rare tabular microcline and orthoclase and lath-shaped plagioclase phenocrysts. The groundmass, which is allotriomorphic granular, is composed of quartz, biotite, hornblende, orthoclase, and plagioclase. The accessory minerals are titanite, apatite, zircon, and magnetite. A little epidote is secondary to hornblende and biotite.

Both areas of granite are cut by dikes of a fine-grained pink apatite, in some places as rich in biotite as the granite and in others poor in this mineral. The granite is also cut by coarse pegmatite dikes and grades into similar pegmatitic masses. Graphic granite is not uncommon and at many points is the transition facies between granite and coarsely crystalline pegmatite. The aplite is, as a rule, older than the pegmatite, although in one case an aplitic dike passes along its strike into a dike with narrow aplitic border and pegmatitic center.

The yellowish outcrops of granite at the base of the ridge are discontinuous, being, as a rule, mere heaps of bowlders partially buried in granite soil. The outcrops near the crest are much more continuous. The granite intrudes Cambrian sediments, and rhyolite flows of Miocene age lie upon its eroded surface. Its age is in consequence post-Cambrian and pre-Tertiary. The granite is also cut by dikes of diorite porphyry presumably of pre-Tertiary age. It is probably of post-Jurassic age.

Diorite porphyry.—Dikes of diorite porphyry reaching a maximum observed width of 40 feet cut the Cambrian rocks and the granite of the Gold Mountain ridge. The rock is greenish in color, contains abundant phenocrysts of white altered feldspar, and tends to weather into spheroidal bowlders. It is probably of pre-Tertiary age.

Rhyolite.—The hills to the southwest of Gold Mountain, the ridge east of the Rattlesnake mine, a number of isolated hills and ridges to the east, south, and southwest of the latter ridge, and a small area northwest of the granite at the west end of the Gold Mountain ridge are composed of rhyolite. The presence of a small outlier of rhyolite on granite, three-fourths of a mile southeast of Tokop, indicates that erosion has removed considerable portions of a once more extensive rhyolite flow.

The most widely distributed type is a lilac-gray rock of lithoidal, in places rather incoherent, groundmass. The medium-sized phenocrysts, which in bulk usually equal the groundmass, are tabular crystals of glassy, unstriated feldspars, often showing blue and purple color plays, and rounded grains of colorless quartz. Smaller plates of biotite are locally present. Pink, purple, and red facies also occur. Black glassy types in which feldspar greatly predominates over quartz, to judge from the hand specimen, may be more properly called latite.

Many of the rhyolite flows are flow breccias, containing abundant inclusions of rhyolite of different colors and textures. Vesicular facies showing flow lines are unusual. Interbedded with the rhyolites are sandy beds which contain normal feldspar and quartz crystals and rounded rhyolite pebbles. These are contemporaneous tuffs of either aqueous or subaerial origin. It is probable that minor flows of basalt were contemporaneous with those of rhyolite, since vesicular basalt fragments are in places included in rhyolite.

The rhyolite occurs in mesa-like ridges whose top is often coincident with the surface of a resistant rhyolite flow. This rock lies unconformably upon granite and Cambrian limestone, and upon its slightly eroded surface basalt flows rest in turn. The rhyolite is to be correlated with that of the Amargosa and Kawich ranges and the Bullfrog Hills and is probably of early Miocene age.

Basalt.—Basalt covers the butte between Old Camp and Tokop and occurs in two small areas to the west of the butte and in a number of small areas 11 miles south of Gold Mountain, resting upon the slightly eroded rhyolite surface. The basalt of the butte just mentioned is a dense dark-gray flow rock, which is vesicular along some bands.

This rock, like some of the basalt of the Panamint Range, is spotted by areas of lighter color. The phenocrysts, which are small and fairly abundant, include striated feldspar, glassy green olivine, and blackish-green pyroxene. The basalt breaks down into rounded bowlders heavily stained by iron oxide. It is later than the rhyolite and is probably contemporaneous with the basalt of Slate Ridge and Mount Jackson and of late Pliocene or early Pleistocene age.

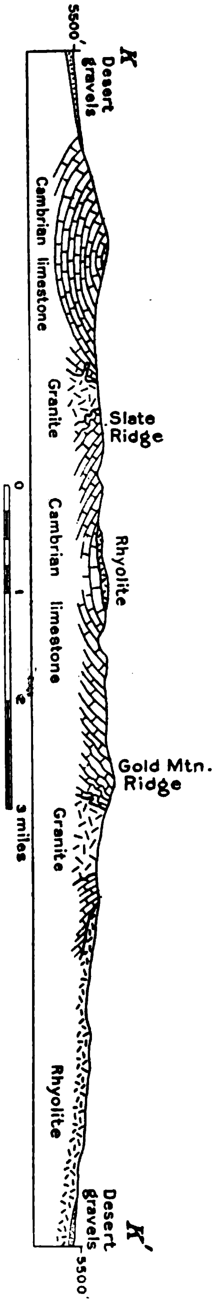

FIG. 16.—Northwest-southeast section across Slate and Gold Mountain ridges.

STRUCTURE.

The Cambrian rocks dip steeply away from the granite batholith, and near-by faults and brecciation, isoclinal folds, and buckled strata are developed. (See fig. 16.) At a distance from the granite the dips become less pronounced, but the mass of granite is so large and the Cambrian masses so small that rather high dips are characteristic throughout them. The granite is cut by fault and joint planes. Prior to the outflow of the rhyolite and basalt the granite and Cambrian rocks had a topography somewhat less rugged than at present, but the Gold Mountain ridge appears to have existed. Blocks of rhyolite north of Grapevine Canyon are tilted in different directions by normal faults, the majority of which strike northeast and southwest.

ECONOMIC GEOLOGY.

The Gold Mountain mining district, organized January 25, 1868, embraces within its limits the Gold Mountain and Slate ridges. Mines have been worked in the district intermittently since that time, and several mills have been built, none of which are now in operation. Old residents estimate the total product of the distrist as $500,000, the concentrates being hauled by wagons to Belmont and Austin, Nev. The mines and prospects lie in the more highly metamorphosed Cambrian rocks and in granite, and these rocks in this vicinity are probably most favorable for prospecting. The contact of the rhyolite and granite 9 miles south of west of Gold Mountain is in places altered to an iron-stained, incoherent mass, cemented by chalcedonic quartz, and this contact is perhaps worthy of examination.

OLD CAMP.

The almost deserted village of Old Camp, near Gold Mountain, is situated 30 miles west of south of Goldfield and 20 miles southeast of Lida. Abandoned mines and prospects are numerous in the vicinity and a number of prospects are being developed 2 or 3 miles south of the village.

The Central mine, which supplied the ore used in the mill at Old Camp, may be taken as a type of ore deposits in the granite of this region. This mine is situated on the side of a deep gulch 1½ miles north of east of the mill. Five tunnels, with an average length of 300 feet, pierce the granite and all are situated on a single vein or system of connecting veins. The feldspars of the granite within 20 feet of the vein are considerably kaolinized and the biotite is bleached or altered to a sericitic mineral. The quartz vein, or rather zone, within which the numerous connecting quartz veinlets and stringers occur, is from 1½ to 6 feet wide, the proportional amount of quartz increasing with the narrowing of the zone. The ordinary veinlets are from 2 to 5 inches wide. The zone also contains many ellipsoidal and globular areas of quartz which, at least in the plane of observation, are independent masses. The quartz zone in some places changes its direction 90° within 100 feet. While minor postmineral faults are common, the displacement ranging from 6 inches to 7 feet, the major changes in strike and dip are evidently parts of the original structure.

The quartz is white and translucent or slightly smoky, with a strong vitreous luster. Vugs with inch-long crystals are rather rare. In places the clear quartz seems to grade into a gray chalcedonic form, the deposition of which by ordinary waters can scarcely be doubted. Isolated crystals of pyrite, with very rare crystals of chalcopyrite and galena, are embedded in the quartz, while the former abundance of pyrite in particular is shown by numerous iron-stained cavities of cubical form. Both hematite and limonite occur in the porous quartz, and where these are abundant gold values rise. An occasional malachite stain and a cerussite coating are also present. Dendrites of manganese dioxide occur in the granite, and are probably derived from the alteration of the granite rather than from a decomposing gangue mineral. Horn silver is reported to be present in small amounts, but was not seen. The ore is free-milling, the arrastres, now abandoned, having saved about 75 per cent of the assay value. Films of a bluish-white chalcedony were noted at a number of places. Some of it was deposited prior to the oxidation of the pyrite and some was deposited after partial or complete oxidation.

While the quartz is rather similar to the quartz of pegmatitic origin in the district, and the form of the ore deposit rather suggests that of a pegmatitic dike, the apparent gradation into chalcedony indicates a less close connection with waters of the granitic magma. Water appears to have filled a most complex zone of fracture with quartz and sulphides, the gold probably being originally contained in pyrite. Later oxidizing waters attacked the sulphides and altered them to oxides and carbonates, setting the gold free. These waters apparently carried some silica in solution, which was deposited as chalcedony.

The mines in the vicinity of Old Camp are situated near water sufficient for mining and milling purposes. Timber for fuel and mining use is standing within 2 or 3 miles. The railroad terminus at Goldfield is 35 miles distant.

TOKOP.

Tokop is 4 miles in an air line northeast of Old Camp and 25 miles by road west of south of Goldfield. The properties of the Gold Crest Mining Company, situated three-fourths of a mile south of Tokop, were examined in some detail. On the Ouida claim a vertical vein cuts the Cambrian garnet-quartz-epidote rock, which strikes N. 10° E. and dips 20° W. This vein is 1½ feet wide and strikes N. 80° W. The quartz of the vein, which is white and semitransparent, has been intensely crushed, and the fragments have been cemented by hematite and limonite. Dendrites of manganese oxide also occur. Some portions of the quartz are compact, with here and there an iron-pyrite cube unaltered, while other portions have a few vugs lined with quartz crystals or are honeycombed with iron-pyrite casts. From the fact that the compact varieties are refractory and the honeycombed varieties are free-milling, it is evident that the gold was set free by the alteration of the pyrite. A mashed greasy phase of the garnet-quartz-epidote rock on one side of the vein is said to pan, but whether pyrite originally occurred in the metamorphosed limestone or whether the values were derived from the surface alteration of the quartz vein is unknown.

Angular fragments of altered limestone and shale are common near the borders of some veins. In such places silicification has extended into the limestone, and these belts, like the quartz veins, weather in relief. Such veins grade into sheared and brecciated zones of silicified limestone, and these again are reported to carry values.

Another vein is similar to the vertical vein first described, but the shattered quartz is cemented by a gray chalcedonic quartz. Still another, at first sight, appears crustified, but close inspection shows that the appearance is due to a longitudinal fracturing of the vein and subsequent filling by limonite and chalcedonic quartz. Both forms of quartz are said to assay, but the earlier quartz appears to carry both the sulphides already mentioned and slight amounts of galena as noted in other veins. It may be that the chalcedonic quartz appears to carry values simply because sufficient care has not been taken to eliminate the older quartz from samples.

Limonite, hematite, cerussite, free gold, and a little malachite were observed as secondary minerals. Probably some chalcopyrite exists at greater depths. One of the last changes which these ore deposits, like those of Old Camp, have undergone is the local deposition of a thin film of bluish-white chalcedony.

The contact of the granite and limestone here probably has locally a rather gentle dip, and deep mines in limestone near the contact may encounter granite. Mr. Joseph Mackedon, the manager of the Gold Crest Mining Company, states that in several prospect holes the quartz veins have past from metamorphosed limestone to granite without diminution in size or value. From the striking resemblance of these veins to those of Old Camp this is to be expected.

Similar veins of iron-stained quartz carrying gold values occur at a number of places in metamorphosed Cambrian rocks around Tokop.

Waters carrying silica and metallic salts in solution appear to have deposited these substances in strong fractures which extend, in some cases, at least, into the granite. The country rock was to a less extent impregnated. The quartz veins were subsequently crushed and iron oxide and chalcedonic silica were deposited in the fractures. Simultaneously, probably, iron pyrite was dissolved and the gold set free.

Water and wood for mining and domestic purposes are near at hand, and the distance to the railroad at Goldfield is 25 miles. The Rattlesnake mine, near the properties described, appears to be in the same rock formation, and its ore deposits and those of Tokop are said to be similar. Eight or ten years ago the Rattlesnake produced $150,000, and recently it has been reopened. The veins of Tokop, like those of Old Camp, seem strong and will probably be permanent to such depths as mining is possible. With depth, however, the ore will become refractory and may become leaner.

ORIENTAL WASH.

Several prospects, now abandoned, are located in the altered limestone west of the granite area at the west end of the Gold Mountain ridge. At one prospect a thin quartz vein cuts the limestone. Malachite, azurite, chrysocolla, and limonite-stained chalcedonic quartz occur in irregular patches and veinlets through the quartz. Vugs occur in the secondary minerals, and the azurite and malachite are in places covered with numerous quartz crystals. A little chalcopyrite is embedded in the oldest quartz and cores of chalcopyrite are surrounded by the secondary copper minerals. A vein of malachite 1 inch in width, apparently replacing the limestone, is exposed in another prospect. At still another prospect, in association with malachite, azurite, and coral-red opaline quartz, heavily stained by manganese dioxide, is a streak from 1½ to 2 inches wide of a canary-yellow granular mineral which appears to replace limestone. Dr. W. F. Hillebrand determined this mineral to be chloropal, a hydrous iron silicate. The general resemblance in structural relations and mineralogic composition of these deposits to those near the granite of the Belted Range at Oak Spring is worthy of note. The nearest water to these prospects is at Sand Spring, 6 miles away, and fuel can be obtained from Gola Mountain within 10 miles. By road the prospects are 45 miles from the railroad terminus at Goldfield.

SLATE RIDGE.

TOPOGRAPHY AND GEOGRAPHY.

Slate Ridge lies between the valley south of Mount Jackson on the north and Oriental Wash and an opposed westward-reaching arm of Sarcobatus Flat on the south. The ridge trends a little north of east, and near its middle is almost severed by opposed gravel-filled valleys. West of the Stateline Mill the ridge is formed of a number of low domelike granite hills, which reach a maximum elevation of 6,500 feet. The hills are rather gently sloping and without prominent rock exposures. From a distance they are yellowish gray in color. East of the Stateline Mill the rocks are largely of sedimentary origin and there is a sharp crest line. The east end of Slate Ridge is a mesa of lava flows which have been considerably dissected. The range is covered by a sparse growth of tree yucca and a little grass grows throughout its extent.

GENERAL GEOLOGY.

The formations exposed in Slate Ridge, from the oldest to the youngest, are the following: Cambrian sedimentary rocks, post-Jurassic granite, pre-Tertiary quartz-monzonite porphyry, pre-Tertiary diorite porphyry, earlier rhyolite, later rhyolite, and basalt.

SEDIMENTARY ROCKS.

Cambrian.—Cambrian rocks form the central part of Slate Ridge and occur in numerous areas isolated in the granite in its west end. Of the latter some are clearly inclusions buoyed up by the granite magma, while others may perhaps be connected with larger masses beneath the surface. Small Cambrian fragments are abundantly included in granite and the earlier rhyolite, particularly near the contact of these rocks with the sediments.

The Cambrian rocks of Slate Ridge are little metamorphosed on the road between Tokop and Goldfield. Here the interbedded series consists of paper-thin olive-green shales, gray limestones, or magnesian limestones, usually rather thin bedded, and some impure medium-grained quartzites of purple, gray, or white color. Rounded hills of gentle slope are developed in these slightly metamorphosed rocks. The Cambrian rocks are intensely metamorphosed near granite, and these facies have been described in the section on the Gold Mountain ridge (p. 183), along which they are more extensively developed.

No fossils were found in these rocks, but from their lithologic similarity to the rocks in the vicinity of Lida and Cuprite they are without much doubt of Lower Cambrian age.

Later tuffs.—Beneath the later rhyolite at several places is exposed a thin band of white tuffaceous sandstones, possibly to be correlated with the later tuffs of the Goldfield hills and Pahute Mesa.

IGNEOUS ROCKS.

Post-Jurassic granite.—Granite forms a considerable batholith on the west end of Slate Ridge and smaller intrusive masses and dikes occur in the Cambrian rocks. This rock is a coarse-grained biotite granite of pinkish tone. The pink or white feldspar and slightly smoky quartz individuals reach a maximum diameter of one-half inch, while the black biotite plates are smaller. The granite tends to weather into spherical masses. The surface of these bowlders appears to undergo a kind of cementation, and on further weathering the hardened surface protrudes beyond the soft interior, forming mushroom-like forms. The granite breaks down into a soil of the constituent minerals and mechanical disintegration is so rapid that recent detrital deposits extend as broad basins well up into the hills. The granite is cut by parallel sheeting in certain localities and on weathering assumes the appearance of a sedimentary rock. Microscopic examination shows the texture to be allotriomorphic. The feldspar is orthoclase, considerably kaolinized and sericitized. Zircon and magnetite are present as accessory minerals.

Dikes of fine-grained biotite aplite, rather more siliceous than the granite, cut it, and these on weathering protrude from the granite mass. The granite is also cut by dikes and in turn grades into irregular masses of coarse-grained pegmatite. Some quartz veins are evidently of pegmatitic origin, since they grade into less siliceous pegmatites. In some instances microscopic examination shows quartz individuals at the contact of granite and pegmatite to be common to both rocks. At the Bullfrog-George mine fluorite and molybdenite occur in a quartz vein which is without much doubt of pegmatitic origin. Molybdenite occurs sporadically in small tablets and irregular areas in and between the quartz individuals. A bright-yellow mineral in minute crystals and tufted aggregates, apparently secondary to molybdenite, was determined by Dr. Waldemar T. Schaller to be molybdite (molybdenum trioxide). Purple fluorite occurs in crevices in the quartz, and fluorite cubes one-fourth inch in diameter also line vugs in the quartz. Microscopic examination shows that the quartz individuals in contact with fluorite possess sharp outlines, showing that they were but little corroded by the introduction of the fluorite, which is probably of pneumatolitic origin.

The granite is similar lithologically to that of Gold Mountain and has like relations to the Cambrian rocks and the Tertiary rhyolite. It is probably of post-Jurassic age.

Pre-Tertiary quartz-monzonite porphyry.—The Cambrian sedimentary rocks on the road from Tokop to Goldfield are cut by dikes which reach a maximum width of 40 feet. The rock is white and dense and contains a few feldspar phenocrysts. It is similar to the quartz-monzonite porphyry already described from the vicinity of Lida and, like it, is probably genetically related to the granite.

Pre-Tertiary diorite porphyry.—The Cambrian rocks and the granite are cut by narrow dikes of a greenish-gray much-altered rock in which some of the prominent kaolinized feldspar phenocrysts are one-half inch long. This is probably the pre-Tertiary diorite porphyry.

Earlier rhyolite.—The earlier rhyolite forms a considerable portion of the east end of Slate Ridge, and small areas of it occur, widely distributed over the central and western portions. In some places east of the Bullfrog-Goldfield road it appears from a distance to protrude from the later rhyolite. The earlier rhyolite is a flow rock of purple, gray, or white color. The groundmass, which is usually lithoidal, is equaled in bulk by the medium-sized phenocrysts of glassy unstriated feldspar, quartz, and biotite. Semituffaceous layers are interbedded with the flows northeast of Tokop. The earlier rhyolite lies upon the eroded surface of the Cambrian rocks and the granites, and in turn is overlain by basalt and the younger rhyolite. It is similar to that of the Amargosa Range and is probably of earlier Miocene age.

Later rhyolite.—The dissected mesa at the east end of Slate Ridge and a number of outliers in the recent gravels east of it are formed of flows of rhyolitic rocks. This later rhyolite has a dense groundmass of deep-brown color, in which are abundant glassy feldspar phenocrysts; in some facies very small and in others medium sized. Microscopic examination proves the groundmass to be a brown glass with well-developed flow lines. The phenocrysts are orthoclase, somewhat corroded, rare and small greenish augite crystals, and very rare quartz grains. While this rock is tentatively here called a rhyolite, chemical analysis might prove it to be of less acidic composition.

Beneath this rhyolite are tuffaceous sandstones in which are rhyolite pebbles. This is probably the later tuff (Pliocene) of the Goldfield hills. The rhyolite immediately above the sandstone is in many places vesicular and is a flow breccia.

This rhyolite is similar lithologically to the later rhyolite of the Goldfield hills, and the two have suffered equal deformation. They are without much doubt contemporaneous lava flows of Pliocene age.

Basalt.—Black vesicular basalt occurs in a number of small outliers upon the Cambrian rocks, the granite, and the earlier rhyolite and as small buttes on the border of Slate Ridge. The basalt is similar lithologically to that of Mount Jackson and, like it, is probably of Pliocene or early Pleistocene age.

STRUCTURE.

The Cambrian rocks at a distance from granitic intrusions lie in gentle folds many of whose axes trend northeast. The folding is comparable in intensity with that at Cuprite and Lida. On the other hand, they dip steeply away from the granite batholith and in its vicinity are buckled and minor isoclinal folds are common. (See fig. 16, p. 187.) It is evident that in this region the Cambrian rocks were folded prior to the intrusion of the granite, a process which superimposed upon the gentle folds complex elements. The granite is cut by normal faults. Since the Tertiary rocks were formed the ridge has suffered domical uplift, centering 4 or 5 miles east of the Stateline Mill.

ECONOMIC GEOLOGY.

Quartz veins, some of which are of pegmatitic origin, cut granite and the more metamorphosed Cambrian rocks. The best prospecting ground is the granite and the metamorphosed limestone and shales in its vicinity. In the late sixties mines were opened on Slate Ridge and considerable ore bodies were removed. The ledge at the Stateline Mill, now abandoned, is said to have been 20 feet wide, the ore averaging $40 per ton in gold. Recently a number of claims have been located in Slate Ridge and development work is now being done.

The Bullfrog-George prospect is situated on the side of a domical granite hill, near the Lida-Old Camp road. The surrounding hills are cut by quartz veins which weather in relief and can be traced for long distances. Some of these contain feldspar and others grade into pegmatite dikes. The Bullfrog-George claims are situated on a quartz vein from 4 to 9 feet wide, which is traceable for about a quarter of a mile. The vein is vertical and strikes N. 70° W. The contact with the granite is in some places gradational, the white translucent quartz of the granite passing into that of the vein without break. In other places the granite appears to have been shattered prior to the deposition of the quartz, which now fills linked cavities in the granite. The feldspars of the granite within 4 feet of the vein are locally much kaolinized. Apparently isolated in the quartz are small areas of pyrite and chalcopyrite, with less galena and chalcocite or a related sulphide. The quartz in many portions is intensely crushed, this crushing perhaps being contemporaneous with faults which cut the diorite-porphyry dikes of the vicinity. The crushed fragments have been recemented by limonite or a chalcedonic quartz intensely stained by limonite. With these knife-edges of limonite and in limonite-stained cavities malachite, cerussite, and traces of azurite occur. Such quartz pans free gold, and coarse pannings were examined from the heavily iron-stained contact of the granite and quartz. At the east end of the quartz veins less shattering was noted. Vugs lined with quartz crystals are common, and here the fluorite and molybdenite already described (see p. 192) occur.

The quartz vein itself appears to be a pegmatite which crystallized while portions of the granite were still viscous and other portions were comparatively solid. Later, faulting occurred and the vein was crushed. Since then limonite and chalcedonic quartz have recemented the quartz fragments. The period at which the sulphide mineralization occurred is unknown. The molybdenite and fluorite are probably of pegmatitic origin, while the sulphides were doubtless deposited later. Similar quartz from other prospects on the ridge was examined. Where iron stained it is said to carry free gold.

Water is at present hauled from a pipe line on the Lida-Old Camp road, 9 miles distant. The nearest timber grows in the vicinity of Old Camp. The prospect is 30 miles from the railroad terminus at Goldfield.

DEATH VALLEY.

TOPOGRAPHY AND GEOGRAPHY.

Death Valley is a deep depression lying between the Panamint Range on the west and the Amargosa Range on the east. The valley, which has a length of 120 miles and a width varying from 3 to 10 miles, unites with the Amargosa Desert at the south end of the Funeral Mountains. In the fifties a band of eighty emigrants are said to have perished here and the valley received its name from this tragedy. In the Pahute language the valley is called Tomesha, meaning "ground afire." Many fantastic stories, most of them wholly without foundation, center in Death Valley. Lives have been lost from year to year, but the majority of such sacrifices have been due to ignorance of desert conditions. In July and August the temperature is reported, apparently on good authority, to reach 136° F., and in summer none but the most desert-hardened men should enter the valley. In winter and fall the climate is delightful. In those portions of the valley which lie beneath sea level the dry air seems heavy and the brightest days are sultry. In the lower portions of the valley no animals other than a few coyotes live, and the oppressive silence is unbroken. Much of the valley is absolutely without vegetation and the adjacent mountain slopes are equally bare. Mesquite grows on the sand area west of Surveyors and Stovepipe wells and at Mesquite Spring. The upper portions of the alluvial slopes have here and there a sparse growth of creosote bush and white sage, and salt grass covers restricted areas around the wells.

The lowest point of Death Valley within the area mapped is about 280 feet below the sea level, but 15 miles farther south the depression is at least 125 feet deeper. The mountain ranges on either side of the valley are from 6,000 to 8,900 feet high, and in consequence of this great difference in elevation the slopes are steep and wide alluvial cones sweep up to the mouths of the deeply scored canyons. The floor of the valley is diversified by numerous hills and low ridges of Tertiary sediments. The part of the valley lying north of a low ridge at the head of Salt Creek is sometimes called Mesquite Flat.

A large sand dune occupies the bottom of Mesquite Flat. Most of the larger sand dunes are without vegetation, while some of the smaller ones (20 feet high and 100 feet in diameter) owe their existence chiefly to the protecting influence of mesquite and similar vegetation (Pl. II, *B*). Death Valley is the only portion of the area surveyed in which sand storms endanger life. The area mapped as sand contains within its limits many small areas of clay and is without doubt partially under water in times of excessive floods. In like manner the playa deposits mapped to the south, north, and east of the sand are studded with minor sand dunes.

South of Salt Creek the center of the valley is a loamy flat covered with salt grass. This passes gradually southward into a salt marsh, 4 miles wide, which, according to Campbell,[a] extends about 25 miles south of the area mapped. It is a dirt-brown flat, containing numerous channels and ponds of stagnant or gently flowing salt water. The soil itself is heavily impregnated with salts, and by fractional recrystallization the margins of the water bodies are coated with glittering white salt deposits. The salt-cemented soil stands up in rugged pinnacles and hummocks from 6 to 18 inches high. Campbell[b] states that a specimen of this material from a point south of Furnace Creek has the following composition:

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[a] Campbell, M. R., Bull. U. S. Geol. Survey No. 200, 1902, p. 18.

[b] Loc. cit.

Analysis of soil from Death Valley.

	Per cent
Chloride of sodium	94.54
Chloride of potassium	.31
Sulphate of sodium	3.53
Sulphate of calcium (hydrous)	.79
Moisture	.14
Undissolved residue (gypsum and clay)	.50
	99.81

This large supply of salt, while at present, as Campbell states, too impure to be of commercial value, may in the future be economically important. From 1883 to 1887 an extensive plant extracted borax from the salts of this marsh, but on the discovery of extensive colemanite deposits in the Tertiary lake beds on Furnace Creek it was closed down. Borax is also reported in the clay of the playa 2 miles east of south of Surveyors Well.

Death Valley is one of the best watered areas within the limits of the area here discussed, and the water for the most part is good. Salt Creek and the warm Indian Springs have already been described (pp. 19, 20). At Stovepipe Wells, Surveyors Well, Ruiz Well, Salt Creek Wells, and the water hole on the Furnace Creek road, 1 mile north of the boundary of this area, water stands in shallow holes dug in the sand and clay. The water of the last-named hole is too salt for man's use, although animals will drink it. Mesquite Spring is a small spring in Recent gravels, while the water of Cow Creek and Triangle Spring flows from Tertiary lake beds.

GENERAL GEOLOGY.

SEDIMENTS.

General statement.—Two sedimentary series much later in age than the Paleozoic rocks of the Amargosa and Panamint ranges outcrop in Death Valley. The one is composed of coarser fragmental material, well rounded, and appears to have been deposited in a wave-swept lake, while the material of the other is angular or subangular and evidently analogous in origin to the present alluvial slopes and fans. Associated with each are finer grained clays and limestones—those of the one series, lake deposits; those of the other, playa deposits. The delineation of these finer deposits on the map is in many cases probably inaccurate. The lake deposits are clearly older than those of the playa and are better cemented and in general more deformed. The two formations, while less extensively developed, are much more easily differentiated on the east side of the Amargosa Range and in the adjoining portions of the Amargosa Desert, where the detrital and playa deposits are uncemented angular gravels, clays, and chemically precipitated limestones, which are particularly undeformed, while the older lake beds are sandstones and well-rounded conglomerates which dip at high angles. Below Ash Meadows, in the Amargosa Desert, Campbell[a] found evidence that the detrital deposits were laid down after the folding and elevation of the lake beds into the Funeral Mountains. The time gap between the two is considerable, and the older beds are tentatively considered by Campbell[b] Eocene and the others Pliocene. It is believed, however, from evidence obtained in the Amargosa Range, that the older beds are probably largely as late as the Miocene and that they may be the shore deposits of Siebert Lake, while the presence of basalt, contemporaneous with the upper portion of the younger beds, indicates that their deposition probably extended into the Pleistocene. The later beds are evidently the equivalent of the older alluvium.

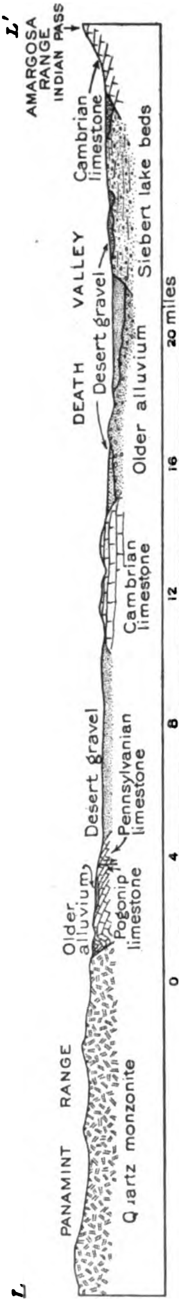

FIG. 17.—East-west section across Death Valley, 6 miles north of boundary of area mapped.

Territory lake beds (including the Siebert lake beds).—The Tertiary lake beds, which are a northwesterly extension of the folded Tertiary sediments extending across the Funeral Mountains southwest of Furnace Creek ranch, are confined, in the area surveyed, to the east side of Death Valley near the boundary. Numerous hills of these beds rise above the Recent gravels, and the scale of the map permits only an approximate representation of their complex distribution.

The Tertiary lake beds consist of white, yellow, and green consolidated clays, friable sandstones with ironstone concretions, rounded and subangular gravels, and thin limestone lenses. Much of the clay shows sun cracks and ripple marks, indicating that the lake was at times shallow and even dry. The subangular form of certain of the gravels indicates that cloudbursts at times spread sheets of detrital deposits over the lake beds. Colemanite and other chemical precipitates interbedded with the other deposits were laid down during periods of unusual evaporation. The more northerly hills to the west of the Daylight Spring-Furnace Creek road were not visited by the writer, but specimens collected by Mr. R. H. Chapman are reddish-brown conglomerates and conglomeratic sandstones with rounded pebbles. The pebbles, which reach a maximum diameter of 2½ inches, are limestone, quartzite, and schist derived from the Amargosa Range. They are probably members of the lake-bed series.

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[a] Campbell, M. R., Bull. U. S. Geol. Survey No. 200, 1902, p. 16.

[b] Loc. cit.

The Tertiary lake beds are folded into open folds, usually with northwest axes. (See fig. 17.) Joints from 4 to 5 feet apart are developed.

Older alluvium.—Hills of the older alluvium diversify the surface of Death Valley, at two places extend a considerable distance up the Amargosa Range, and form the north end of the Panamint Range. In the large sand area north of Salt Creek a few hillocks of slightly consolidated clay occur, and these probably indicate the former extension of these deposits across the valley.

The road from Daylight Spring to Stovepipe Wells passes through a desiccated ridge from 200 to 400 feet high, which trends northwest and southeast and is cut by antecedent drainage lines. Next to the Amargosa Range the hills are composed of slightly consolidated beds of angular or subangular bowlders and bands of gravel and sand. Cross-bedding and local unconformities are common. Well-developed joints form buttresses on the main cliffs, and large bowlders crown many of the high pinnacles. Within one-half mile of the western edge of the hills the sand beds are replaced along their strike by clay, and clay layers wedge in between the bowlder beds. At the western edge of the hills the base of the series is clay and the top bowlder beds. A section measured 2 miles south of east of Stovepipe Wells is as follows:

Section in Death Valley near Stovepipe Wells.

	Feet.
Angular bowlder beds, similar to those of the present alluvial slopes	150+
Clay and bowlder beds in equal development	110
Salmon-pink clay beds, from 3 inches to 3 feet thick; a few layers of angular bowlders interbedded	100

At Triangle Spring fine-grained, dirty-brown cellular limestone is interbedded with the clays. The limestone shows desiccation cracks. Compact, fine-grained, light-colored limestone and caramel-brown mammillary gypsum also occur here. The beds exposed at Salt Creek include yellow, white, and green clays, with here and there a thin bed of white limestone. Brownish beds of angular bowlders constitute a considerable portion of the upper part of the section. The long ribbon of these deposits near the Grapevine Mountains northeast of Surveyors Well consists of tawny-yellow clays and thin beds of cellular limestone. At Grapevine Springs the deposits consist of limestones and fine clays. The clay contained crystal aggregates of selenite. The limestone is white or gray in color and is partly compact and very finely laminated and partly porous. The areas in the middle of the valley northwest of these springs are of interest, since flows of the supposed Pleistocene basalt are interbedded with the clay, while other layers contain bowlders of basalt. In some places the clay beneath the basalt has been reddened and slightly baked. These clay beds, which are well up in the section, are broadly contemporaneous with basalt eruption.

About 2,500 feet of the older alluvium is exposed in the Amargosa Range, and it is probable that the series was originally over 3,000 feet thick. The beds are gently flexed, and dips from the mountains to the valley axis predominate, particularly in the northern part of the valley. The sediments have been jointed, the principal system striking N. 25° W., and along some of these joints occur normal faults with from 2 to 4 feet displacement.

GEOLOGIC HISTORY.

In Tertiary, probably early and middle Miocene time, Death Valley did not exist, Amargosa and Panamint ranges were low, and their southern portions[a] at least were covered by a lake which extended well into the present Death Valley south of Salt Creek. This lake was at least partly contemporaneous and may have been connected with that in which the Siebert lake beds were deposited, and which probably at one time covered almost the entire area surveyed. In late Pliocene time, however, Death Valley was probably a closed basin, occupied by a sheet of water, which appears to have been a playa. This playa varied widely from time to time in extent and was bordered by the uplifted Panamint and Amargosa ranges. Before the deposition of the older alluvium ceased the inwash of material from the mountains raised the center of the valley hundreds of feet above the present level. Alluvial slopes, much like those of to-day, extended well up on the Panamint and Amargosa ranges. In the playa great thicknesses of clay were deposited, and at periods of unusual desiccation limestone and gypsum were precipitated. Unusual floods from time to time throughout the period of deposition spread thin layers of bowlders over the playa. Basalt outflows accompanied the deposition of the upper playa deposits.

Death Valley is believed to have been roughly blocked out in late Miocene and early Pliocene time, through erosion and deformation, including faulting and possibly folding. The folding of the Amargosa and Panamint ranges does not alone account for the valley, and it appears to be a block dropped down between the bounding ranges by faults. The earliest structural lines, probably of late Miocene age, trend northwest and southeast and include the fault[b] on the north-

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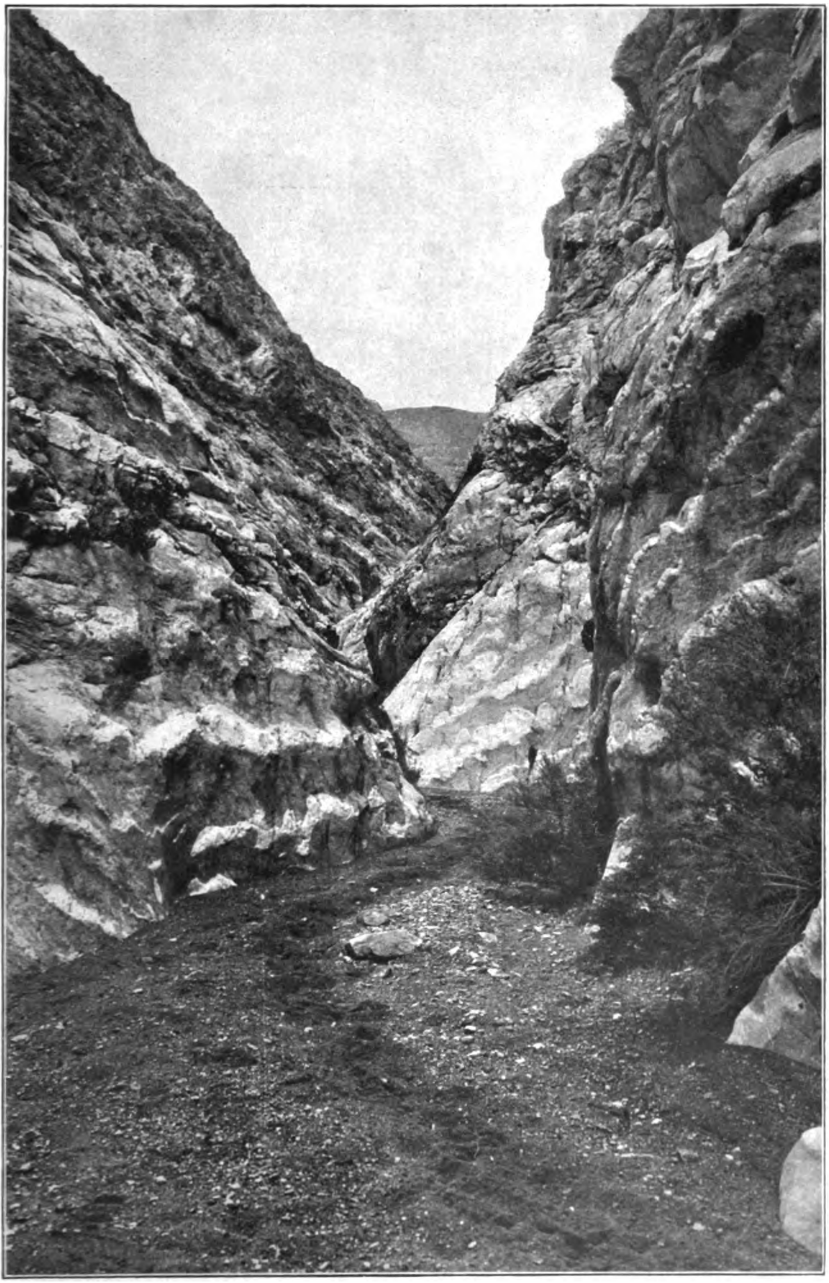
[a] Spurr, J. E., Bull. U. S. Geol. Survey No. 208, 1903, pp. 189, 202.

[b] Campbell, M. R., Bull. U. S. Geol. Survey No. 200, 1902, p. 16.



MARBLE CANYON, PANAMINT RANGE.

Showing metamorphosed Pogonip limestone near quartz-monzonite batholith.

east side of the lake beds in the Funeral Mountains and normal faults in the Panamint Range. In early Pleistocene time the lines of disturbance were north-northwest, and normal faults, with a strike parallel to the valley axis, occur in the older alluvium east of Stovepipe Wells. In the Panamint Range 22 miles beyond the boundary of the area mapped and in line with Death Valley a narrow block, apparently faulted into the older rocks, has, at a distance of 15 miles, the appearance of the older alluvium. The fronts of the Panamint and Amargosa ranges facing Death Valley are very steep and may be due to the erosional shifting of a fault scarp. The absence of Paleozoic inliers in the valley indicates the steep grade with which these rocks descend beneath the valley gravels. That the drainage lines of the Panamint and Amargosa ranges flowing into Death Valley have been revived in comparatively late geologic time is indicated by the intense dissection of the prebasaltic mature topography of the Panamint and Amargosa ranges. (See pp. 202 and 161.) The history of Death Valley has been complex, and the solution of the problem requires more detailed work than was possible in the present reconnaissance.

ECONOMIC GEOLOGY.

Extensive deposits of colemanite and other borax minerals occur in the Tertiary lake beds near Furnace Creek, and the extension of these beds in the area mapped is worthy of careful prospecting. "Marsh" borax has been found 2 miles south of Surveyors Well, and it is probable that this has been leached from the older alluvium near by. The clays and limestone of this formation may contain important colemanite deposits.

PANAMINT RANGE.

TOPOGRAPHY AND GEOGRAPHY.

The Panamint Range is 130 miles long and trends north-northwest parallel to the Sierra Nevada. At its north end lava mesas unite it with the Amargosa Range; its south end passes into low hills of Tertiary sediments and lavas capped by later basic volcanics.[a] The ascent from Death Valley on the east ranges from 6,000 to 11,000 feet, while that from Panamint and Termination valleys on the west is almost as great. The range culminates 20 miles south of the area here mapped in Telescope Peak, which the Wheeler survey determined to be 10,938 feet high. Within the area the highest point is Tin Mountain, whose elevation is 8,900 feet. The range crest is somewhat west of the center, and the western slope seems a succession of cliffs and declivities. The range is scored by deep canyons, some of which are comparable with the most famous gorges of the Rocky Mountains. Marble Canyon (Pl. III) is particularly impressive. The sharply curving inner canyon, which is but 10 feet wide, is overhung by walls 200 feet high, and many portions of the stream channel are in perpetual shadow. The walls are beautifully smoothed and rounded by erosion 75 feet above the stream bed. Rock cliffs 10 to 100 feet high, which in other regions would form waterfalls, break the more gentle grades of gravel. The brilliant yellows, reds, whites, and blacks of the limestone enhance the beauty due to form.

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[a] Spurr, J. E., Bull. U. S. Geol. Survey No. 208, 1903, p. 201.

The crest of the range is characterized by an older, more mature topography, with well-graded stream channels and gently rounded peaks and slopes. Near the southern boundary of the area mapped and for a distance of 4 miles south of Tin Mountain this belt is 3 miles wide, while the intermediate belt along the crest line is but 1 mile wide. Remnants occur in favorable positions on the middle slopes of the mountain range above an elevation of 5,000 feet. On the southern border of the area the basalt covers a portion of this surface—a fact which indicates that the surface was probably developed in Pliocene time. The older alluvium, in part, is formed of remnants of the alluvial slopes, the gravel pediment of this subdued mountain range.

Sparse growths of piñon and juniper cover the southwest corner of the area and the northeastern and southern slopes of Tin Mountain, while cottonwood and willow grow along Cottonwood Creek. Grass is found around the small playa northwest of Goldbelt Spring and in the valleys in the higher portion of the range. The Panamint Range, because of its elevation, has a heavier annual precipitation than most of the other ranges. One or more springs rise in nearly all the main gulches tributary to Cottonwood and Marble Canyon creeks. Several springs lie south of Tin Mountain. Emigrant Spring, to the south of the area mapped, flows 1,100 gallons of water per day.

GENERAL GEOLOGY.

The formations of the Panamint Range, from the oldest to the youngest, are as follows: Prospect Mountain quartzite (?), Pogonip limestone, Pennsylvanian limestone, earlier quartz-monzonite porphyry, post-Jurassic granitoid rocks (quartz monzonite, soda syenite, and granite), later quartz-monzonite porphyry, older alluvium, basalt, and Recent alluvium.

SEDIMENTARY ROCKS.

Prospect Mountain quartzite (?).—Tucki Mountain is formed of metamorphosed sediments identified with the supposed Prospect Mountain quartzite of the Amargosa Range. (See p. 162.)

Pogonip limestone.—The most widely distributed formation of the Panamint Range is the Pogonip limestone, of which at least 3,000 feet is exposed. The limestone, which is compact and fine grained, ranges in color from dark gray to black. The dark color is, at least in part, due to carbonaceous matter, since some beds are fetid, and when heated exude a tarry substance. The bedding is, as a rule, massive, although some slightly argillaceous facies are thin bedded. Cross-bedding was noted in several places. Near the top of the section occur layers and lenses of black, semitranslucent flint from one-half inch to 3 inches thick, separated by bands of limestone from 1 to 18 inches thick. In other beds globular and ellipsoidal flint concretions from one-fourth inch to 3 inches in diameter are abundant. A quartzite layer interbedded with the limestone occurs rather well up in the formation. The rugged exposures of this white or pinkish-white fine-grained quartzite outcrop on the western side of the playa 4 miles north of Goldbelt Spring. The bed of quartzite is 100 feet thick and has thin bands of limestone interbedded near its base, and especially near its top. Four miles south of Tin Mountain Mr. T. C. Spaulding noted interbedded in the limestone a 30-foot band of muscovite schist. The schist is less metamorphosed than that of Tucki Mountain.

At one locality the writer collected fragmentary fossils which Mr. E. O. Ulrich states include a shell belonging either to *Maclurea* or some related genus and a fragment of a pelecypod. These indicate undoubtedly Ordovician and probably Stones River age. Near the playa to the north of Goldbelt Spring Messrs. Chapman and Spaulding collected fossils of which the gasteropods, Mr. Ulrich states, remind one of Baltic Ordovician species and indicate a lower Ordovician horizon. The fossils include a very large *Helicotoma*-like shell; *Eccyliopterus* sp. undet., of large size and with contiguous whorls; *Receptaculites* sp. nov., obconical, with thick walls and small, crowded stolons. Not only in its organic remains, but also in its lithologic character, this limestone resembles the Pogonip limestone present in many of the ranges in the area surveyed. It was deposited in water of shallow or medium depth, a conclusion indicated by the presence here and there of cross-bedding and abundant organic remains. With the accumulation of the limy sediments the sea bottom must have been depressed step by step, an inference drawn from the great uniformity and thickness of the limestone.

Pennsylvanian limestone.—The Pennsylvanian limestone forms a narrow band along the east front of the Panamint Range. It is separated from the Pogonip limestone to the west by a fault of several thousand feet displacement. This limestone, of which probably some 1,500 feet is exposed, is fine grained and gray or dark gray in color. Some of the darker limestone when struck with a hammer gives off a fetid odor. Lenses and ellipsoid masses of black flint occur in some beds. To the west of the soda-syenite area is a bed 75 feet thick of white, fine-grained quartzose sandstone. This sandstone, as well as some beds of limestone, is cross-bedded.

From one locality the following Pennsylvanian fossils, determined by Dr. George H. Girty, were collected:

- Fusulina sp.
- Crinoidal fragments.
- Fenestella sp.
- Small indeterminable gasteropod.
- Indeterminable fragments.

Fragmentary fossils were collected from two other localities, and concerning these Doctor Girty states that while they are undoubtedly Carboniferous, they indicate nothing further.

Older alluvium.—On either side of Emigrant Wash and at the north end of the Panamint Range are a number of areas of the older alluvium. The deposit east of Emigrant Wash forms intensely dissected hills which are continuations of the ridges of Tucki Mountain. The two large areas across the valley to the northwest are eastward-sloping plains cut by erosion into low hills, and each is separated from Death Valley by a low ridge of Paleozoic limestone. A few small outliers occur higher up in the mountains at a maximum altitude of 5,000 feet.

These deposits are composed of beds of angular bowlders and well-stratified sand. These are locally so well cemented by calcium carbonate that caves 25 feet high exist in them. Around Emigrant Spring, in the southern extension of the area west of Tucki Mountain and in the area at the north end of the Panamint Range, white and pink clay similar to that of the present playa deposits is interbedded with the bowlder beds. At the north end of the range the series has an exposed thickness of 2,500 feet.

Recent desert gravels unconformably overlie the older alluvium, which in turn lies upon the eroded surface of the quartz-monzonite and Paleozoic rocks. The upper portion of the series and the basalt are contemporaneous, and in consequence the older alluvium is probably of Pliocene and early Pleistocene age. In Pliocene-Pleistocene time, when Death Valley was occupied by an extensive playa, the Panamint Range was comparatively low and insignificant. The older alluvium areas are the remnants of alluvial slopes which once fringed its borders. These alluvial slopes near Goldbelt Spring reached an elevation of 5,000 feet, while to the north of Tin Mountain no remnants remain above 4,000 feet. Considerable portions of the Tin and Tucki mountain deposits are formed of playa clays, showing that during periods of exceptional rainfall the playa of Death Valley extended well up on the Panamint Range.

Recent alluvium.—The valley above the head of Cottonwood Creek is covered with coarse soil and loam. A more resistant portion of the quartz monzonite has narrowed and partially dammed the valley, and behind this barrier the material washed from the surrounding hills has accumulated. Four miles north of Goldbelt Spring is a basin whose bottom in depressed 275 feet below the inclosing rim of hills.

The basin is in Pogonip limestone and is probably the site of an ancient sink hole formed when the climate was less arid. Later the channel became obstructed by the inwash of débris from the surrounding hills, and eventually alluvial slopes and a playa were formed.

IGNEOUS ROCKS.

Earlier quartz-monzonite porphyry.—A few small fragments of a fine-grained, medium-gray igneous rock are included in the quartz monzonite in the southwest corner of the area mapped. Similar inclusions in the granite of Gold Mountain prove, on microscopic examination, to be quartz-monzonite porphyry.

Quartz monzonite.—A batholith of quartz monzonite underlies 75 square miles in the southwest corner of the area surveyed. The rock is light to medium gray in color, rarely pinkish gray. The minerals visible to the unaided eye are predominant gray feldspar, a greenish-black mineral, either amphibole or pyroxene, bronze-brown biotite, and pink feldspar, while small individuals of magnetite and seal-brown titanite are also visible in places. As a whole biotite is almost as abundant as hornblende, but it appears to be totally lacking over restricted masses. The diameter of the component minerals varies throughout the mass from one-fourth to one thirty-second of an inch. In many places the gray feldspars occur as well-developed tablets up to three-fourths of an inch in length and impart to the rock a porphyritic aspect. Green epidote in granules replaces the hornblende and biotite more or less completely, while veins of epidote cut the rock, and felts of this mineral are common on joint surfaces. Calcite veins are less common. The monzonite is cut by joint planes from 1 foot to 5 feet apart. In weathering the joint blocks become slightly rounded and finally disintegrate into soil. The monzonite forms rugged ridges. The outcrops are usually low bosses or bowlderlike masses, and many of the hills have the appearance of moraines, upon which large bowlders are prominent.

Under the microscope the rock shows an allotriomorphic granular texture, although some of the smaller plagioclase individuals form laths. The essential constituents, in order of abundance, are plagioclase, orthoclase, piotite, quartz, hornblende, and ugite. The accessory minerals are apatite, magnetite, and titanite. Disks of micropegmatite lie between the other constitutents and are inclosed in the feldspars. Some hornblende is secondary to augite, while kaolin, sericite, and epidote form at the expense of the feldspars. The rock is on the border line between quartz monzonite and granodiorite.

The monzonite is cut by thin dikes of a fine-grained pink aplite composed of feldspar and some hornblende. Quartz is sometimes seen in the rock, which then appears to be of granitic composition. The dikes are usually simple. Under the microscope this rock shows the composition of an acidic quartz monzonite, containing a little biotite altered to chlorite. The accessory minerals are the same as those of the quartz monzonite. Some of the aplite is blotched by globular aggregates of coarser hornblende from 1 inch to 4 inches in diameter. These aggregates are formed by the segregation of hornblende from the surrounding rock and are rimmed by halos of almost pure feldspar in individuals from one-half to 1 inch wide. The aplite is probably but a later differentiation product of the monzonitic magma.

Scattered throughout the monzonite are segregations of hornblende from 2 to 3 inches in diameter. These represent a threefold enrichment in hornblende by magmatic differentiation.

The monzonite is cut by and grades into thin dikes of coarser grained rock, locally having the same composition as the monzonite, but usually of more acidic constitution. The individuals of these pegmatite dikes reach a maximum diameter of 2 inches. Some of the dikes have basic borders composed of almost pure hornblende, with a median band of feldspar. While the boundary planes are rather distinct, individual crystals extend from the monzonite into the basic bands and from these into the acidic center. The more acidic portion of this pegmatite shows under the microscope the composition of a soda syenite, containing orthoclase, anorthoclase, augite, hornblende, biotite, quartz, titanite, magnetite, apatite, and zircon. The augite probably contains a little of the ægirite molecule. Other forms of the pegmatite are composed of quartz, pinkish-gray feldspar, and hornblende, named in the order of abundance and the reverse order of solidification. Some limonite pseudomorphs after pyrite occur in the pegmatite, but the original character of the pyrite was not determined beyond doubt. In other pegmatites partial crystals of ferromagnesian minerals are inclosed in a coarse crystalline aggregate of feldspar. Microscopic examination showed that orthoclase and microperthite are so predominant over plagioclase in this rock that it has the composition and texture of a syenite porphyry. The ferromagnesian minerals include augite, olivine, brown hornblende, and biotite. Apatite occurs in unusually large crystals and magnetite in grains.. Miarolitic openings occur in this pegmatite and crystals of the constituent minerals protrude into them. The pegmatite therefore consolidated under less pressure than the monzonite, which lacks such cavities, or its composition was more favorable to their production. The pegmatite is evidently but a late intrusion of the monzonite-magma residuum. Not only is the pegmatite more acidic than the quartz monzonite, but it has undergone an enrichment in soda, linking the quartz monzonite to the soda syenite next to be described.

The batholith sends thin dikes into the Pogonip limestone. At the contact the limestone is considerably disturbed and dips sharply, usually away from the monzonite mass. The small limestone area inclosed by monzonite on the southern border of the area appears to have been buoyed up on the surface of the molten rock. Smaller inclusions are common. An aureole of limestone from one-fourth to 1 mile wide is metamorphosed to a rather coarse-grained gray marble. In this marble are bands, lenses, and irregular bodies of white marble. Large brown garnets, epidote, serpentine, and tremolite are present in the metamorphosed limestone. The two latter minerals occur in veins as well as in sporadic masses through the limestone.

The quartz monzonite intrudes Pogonip limestone and is cut by pre-Tertiary diorite porphyry. It is presumably contemporaneous with the post-Jurassic granite, since intermediate facies between it and the granite, described on page 208, appear to exist. It is rather similar in mineralogic composition to the post-Jurassic granodiorites of the Sierra Nevada.

Soda syenite.—About 11½ miles southeast of Tin Mountain there is a very irregular mass of soda syenite and soda-syenite porphyry, 300 feet long and 200 feet wide. It intrudes the Pennsylvanian limestone and sends into it many straight-walled dikes and ramifying veins of varying width. Prior to recent erosion the limestone appears to have covered the syenite. Bowlders of similar rock occur in the gulch due west of this area, but the masses from which these were derived were not located. Similar rock appears from a distance to form a small area 4 miles west of Lost Wagons. The soda syenite is characterized by abrupt and great changes in granularity and in the relative abundance of the constituent minerals. The predominant form is a coarse- to medium-grained rock of gray color, composed of predominant gray with some pink feldspar, subordinate greenish-black amphibole or pyroxene, and black mica. Many of the feldspars have good crystal outlines and in the more porphyritic facies the abundant feldspar laths have a length of 1½ inches and are aligned in flow orientation. The rock next to the limestone is very fine grained. Epidote has developed at the expense of the hornblende and biotite in all facies. Under the miscroscope this rock proves to be a soda syenite or nordmarkite of hypidiomorphic and uneven granular texture. The predominant constituents are alkali feldspars, including the species orthoclase, microperthite, and anorthoclase. With these is a little oligoclase. The alkali feldspars form rude tabular crystals, many of which are twinned according to the Carlsbad law. Between these tabular forms are anhedra of augite, quartz, biotite, and yellowish-brown garnet. The augite verges toward ægirite-augite. The accessory minerals are titanite, magnetite, apatite, and fluorite. The fluorite flecks the alkali feldspar and may be original or introduced by magmatic gases.

The soda syenite is cut by dikes of compact greenish-gray aplitic rocks. Pink feldspar is associated with the gray feldspar and pyroxene and it alone forms some veins. The aplite under the microscope has a very uneven-grained allotriomorphic texture. The feldspars include microperthite, orthoclase, and some anorthoclase. A little quartz is also present. While the rock is not rich in ferromagnesian minerals, there are many small grains and partial crystals of ægirite-augite. This mineral shows the usual zonal structure, with deeper green bands on the border. Irregular grains of a light-yellow garnet are rather abundant. The accessories are titanite and apatite. Fluorite occurs in small blebs, surrounded by a mesh of sericite shreds, which were probably formed by the same gases that deposited the fluorite. Calcite is also present and its contacts with other minerals are so sharp that it was probably deposited in miarolitic openings. The contact between the aplite and the syenite is in some cases sharp, in others gradational. In one instance a dike of syenite porphyry is faulted by an aplitic dike, but there can be little doubt that the two are genetically related. Narrow pegmatitic dikes, the feldspar and pyroxene of which reach a diameter of 1 inch, occur.

The limestone immediately adjoining the igneous mass is metamorphosed to a coarse- or fine-grained white marble, through which small plates and veinlets of tremolite are scattered.

The soda syenite intrudes Pennsylvanian limestone and has suffered practically the same deformation as the quartz monzonite, and it may well be, as indicated by the monzonite-pegmatite, a later variant of the same magna.

Granite.—A considerable area of biotite granite occurs to the east of the Emigrant Wash, 3 miles south of the area surveyed. Dikes of muscovite granite, genetically related to the biotite granite, were observed cutting the Cambrian rocks 1 mile south of Tucki Mountain, and a few probably occur in the area surveyed. This granite is probably of post-Jurassic age.

Later quartz-monzonite porphyry.—Four miles south of Tin Mountain is an area of siliceous quartz-monzonite porphyry, probably intrusive in the Pogonip limestone. This area was not seen by the writer, but specimens collected by Mr. R. H. Chapman closely resemble the white quartz-monzonite porphyry of the Silver Peak Range, and, like it, this rock is probably genetically related to the intrusion of the post-Jurassic granitoid rocks. Under the microscope the phenocrysts of quartz, orthoclase, plagioclase, and biotite are seen to be embedded in the finely granular groundmass of microcline, plagioclase, quartz, and biotite. The accessory minerals are magnetite, titanite, and apatite.

Diorite porphyry.—Dikes of diorite porphyry from 2 to 6 feet wide cut the quartz-monzonite batholith in the southwest corner of the area surveyed. The rock is light greenish gray in color and has prominent white feldspar phenocrysts from one-eighth to one-fourth inch in length, which are in parallel alignment through flow. The rock has suffered considerable epidotization. Under the microscope it proves to be a much-altered diorite porphyry with a groundmass of plagioclase laths and a little orthoclase. Aggregates of epidote, zoisite, and chlorite and a smaller amount of calcite are evidently pseudomorphs of plagioclase and hornblende phenocrysts. This rock is evidently the pre-Tertiary diorite porphyry.

Basalt.—Six small masses of basalt occur in the southern portion of the Panamint Range, and the same rock caps a considerable area at the north end of the range, where it occurs in several flows, each 500 or more feet thick, interbedded with the older alluvium. The small basalt mass 1¾ miles south of west of the head of Cottonwood Creek is a north-south dike 250 feet wide. The basalt on the borders of this dike is vesicular and includes numerous quartz-monzonite fragments. The outcrop on the Cottonwood Canyon trail three-fourths of a mile above its entrance into the mountains may also be a dike cutting the Carboniferous limestone. The other masses are erosional remnants of a single flow or of contemporaneous flows. The prebasaltic mature Panamint Range in consequence must have been cut deeply by canyons on its borders, while the old surface to the south and southwest of the area mapped was but little dissected when the basalt was extruded. The flow on the east side of Emigrant Wash forms a black bluff 200 feet high, which is a prominent landmark for many miles. The flow 4 miles east of the dike is 400 feet thick and forms a mesa.

The basalt has a dense dark-gray groundmass mottled by light-gray areas. It is more or less vesicular, the largest cavities being 2 inches long and usually elongated parallel to the direction of flow. Calcite, quartz, and zeolites fill the vesicles more or less completely. The phenocrysts, which are usually subordinate to the groundmass, include blebs of olivine, more or less altered, and striated feldspars up to one-fourth inch in length, some of them showing zonal growth. Greenish-black augite is less commonly present. Under the microscope the basalt shows a dark, greasy groundmass, in which are microlitic laths of basic plagioclase and pyroxene columns. The phenocrysts include laths of basic plagioclase; rounded grains of olivine, usually fresh, although in places altered to iron-stained serpentine, and columns of grayish pyroxene, much of it twinned. The basalt is usually well jointed and weathers into spheroidal masses.

The basalt east of Emigrant Wash and the flow on the Cottonwood Canyon trail lie unconformably below the older alluvium. The flows at the north end of the range and others near Emigrant Spring are interbedded with the same formation. The deposition of the upper part of the older alluvium and the effusion of the basalt were therefore contemporaneous, although the latter process continued after the former had ceased. The basalt is probably of the late Pliocene and early Pleistocene age.

STRUCTURE.

The structural history of the Panamint Range has doubtless been as complex as that of the Amargosa Range, but the absence of Miocene formations removes the means by which the pre-Tertiary and middle Tertiary folding can be differentiated. It is, however, evident that the Paleozoic rocks were folded prior to the intrusion of the post-Jurassic igneous rocks.

Tucki Mountain appears to be the northward-pitching end of a north-south canoe, the western side of which is buried beneath Emigrant Wash or has been faulted off. The Cambrian rocks show well the differential folding suffered by a heterogeneous rock series. The schist is typically closely folded and even crenulated; the limestone bands are less strongly folded while the folds of the quartzite are open. The lithologic character of the series renders the detection of the many faults difficult. The folding of the Pogonip and Pennsylvanian limestones is complex, although in its minor details less intense than that of the Amargosa Range, since overturned folds and isoclinals are unusual. The major fold is an anticline, the axis of which is situated near the western border of the area and trends a little west of north. The eastern arm of the fold is long and dips gently eastward. Superimposed upon it are many minor parallel folds, while cross folds with east-west axes cross it. This fold appears to die out a short distance south of Tin Mountain and here the strata are approximately horizontal. The earlier folding was apparently accompanied by reverse strike faulting. The intrusion of the quartz monzonite in the southwest corner of the area mapped considerably disturbed the limestones in its immediate vicinity. They are buckled and dip steeply, usually away from the batholith. Faulting has occured at the contact, as well as in the quartz-monzonite mass itself.

The fault between the Pogonip and Pennsylvanian limestones is presumably a normal fault and is certainly of several thousand feet displacement. Its position is only approximately shown on the map. Small normal faults of northwesterly strike are common in the Pennsylvanian limestone near Death Valley, and these were probably formed when the valley originated. Similar faults with 2 to 4 feet displacement occur in the older alluvium, and this formation has been uplifted and tilted toward Death Valley in places as much as 15°.

ECONOMIC GEOLOGY.

No mining camp exists in the portion of the Panamint Range included in the area under consideration. Harrisburg lies near the Emigrant Spring-Ballarat road, about 6 miles south of the boundary. Assays reported by prospectors indicate that gold-bearing copper ores occur in the quartz monzonite and silver-bearing galena ores in the limestone areas.

Goldbelt, a deserted camp, is situated at the Goldbelt Spring, near the contact of the Pogonip limestone, here marmorized, and the quartz monzonite. A number of men are said to have rushed to this camp in the spring of 1905, but little work was done. The more important development work was on certain thin veins or lenses in the quartz monzonite. The ore contains a little chalcopyrite, probably a portion of the original sulphide unaltered. Of later origin are malachite, chrysocolla, and a dark-brown or black, iron-stained, flinty chalcedony, of approximately contemporaneous age. These minerals are coated with small quartz crystals. This ore is said to have panned free gold. Similar ore is reported from other localities in this monzonite area. A specimen from a vein near the source of Cottonwood Creek consists of dark limonite-stained jasperoid and chrysocolla, in which occur radial crystals of bottle-green brochantite. This also is reported to pan gold. In the soda-syenite mass 6½ miles southeast of Tin Mountain thin veins of limonite, presumably after iron sulphide, occur.

The areas most favorable to prospecting for precious metals are the Cambrian rocks of Tucki Mountain and the Pogonip limestone in the vicinity of the quartz-monzonite mass. Quartz veins, usually of lenslike form, are common on Tucki Mountain. They reach an observed maximum width of 3 feet and usually appear barren, although in some instances they have been crushed and are heavily stained by limonite and hematite. It is said that an old lead mine was at one time worked on this mountain, and several promising camps in the Amargosa Range are situated on similar veins in the same rocks. Veins of two ages in the Pogonip limestone are formed of barren-looking calcite. Some occupy overthrust fault fissures, and these are faulted by other veins. The older veins are composed of massive crystalline calcite; the younger are often beautifully crustified. On the Cottonwood Canyon trail magnificent calcite veins 4 feet wide occupy fault fissures. The crustified calcite curves around included fragments of limestone in concentric bands. Near the quartz-monzonite masses a few small quartz veins occur and some of these contain pyrite. In other portions of the area surveyed ore-bearing veins have been found in limestone near granite contacts, and by analogy they probably also exist near the related monzonite. At a number of places in the limestone the rock is heavily stained by hematite and limonite. In some cases at least these appear to be gossan deposits and the determination of the underlying sulphides might prove profitable.

The older alluvium is contemporaneous with rocks of Death Valley in which some borax minerals have been found. With the possible exception, however, of the area north of Tin Mountain and one up Emigrant Wash beyond the boundary, the Panamint Range is not worth prospecting for borax.

INDEX.

A. Page.

- Acknowledgments to those aiding... 13-14
- Adams, John, discoveries by... 110
- Alaskite, definition of... 37
  - occurrence and character of... 58, 178-179
- Alkali Spring, description of... 19-20, 89
  - rocks near... 57-59, 62-63, 96
  - water of, analysis of... 19
- Alkali Spring Flat, description of... 76-77
- Alluvium, occurrence and character of... 52, 78, 166-167, 178, 190, 204-205
- Amargosa Desert, depth to water in... 159
  - description of... 158-160
  - geology of... 36, 158-160
  - section across, figure showing... 21
  - sections in... 159, 160
- Amargosa mine, rocks in... 35
- Amargosa Mountain system, descriptive geology of... 160—195
- Amargosa Range, economic geology of... 173-176
  - geologic history of... 200
  - geology of.. 27-29, 31-34, 41, 106, 162-172, 199-200
  - prospecting in... 175-176
  - structure of... 172-17[illegible]
  - topography of... 160-162
- Amargosa River, description of... 18
  - springs in... 157
- Ambocœlia sp., occurrence of... 122
- Ammonia tanks, rocks near... 136
  - water in... 131
- Andesite, definition of... 37
  - occurrence and character of... 32, 61, 72, 73, 94-95, 96, 125, 135-136, 167-168, 179-180
- Animals, abundancy of... 23
- Antelope Spring, description of... 89
  - rocks near... 90-91, 93-94
  - water from... 138
- Aplite, definition of... 37
- Archæocidras sp., occurrence of... 122
- Area of district... 14
- Ash Meadows, section in... 160
  - springs at... 20
  - wells in... 159
    - section of... 159
- Aviculipecten sp., occurrence of... 122

B.

- Bare Mountain, economic geology of.. 45, 156-157
  - geology of... 154-156
  - section of... 154
  - structure of... 156
  - topography of... 153-154
- Basalt, definition of... 37
  - occurrence and character of... 32, 33, 62, 68, 74, 75-76, 79-80, 87, 95, 96-97, 98-99, 105-107, 116, 127, 146-147, 151-152, 153 156, 170-171, 181, 186-187, 194, 209-210

Page.

- Basalt, topography due to, view of... 36
- Beatty description of... 25
- Bell, T J., discoveries by... 81
- Belted Peak, altitude of... 118
  - section through, figure showing... 126
- Belted Range, economic geology of... 128-131
  - geology of.. 28-29, 30, 32, 42, 105, 107, 115, 119-127
  - location of... 118
  - section across... 122
    - figures showing... 119, 126, 127
  - structure of... 128
  - topography of... 118-119
- Benedict, S. G., work of... 13, 141
- Bibliography of region... 15-16
- Big Dune, rocks near... 175
- Billingsella, occurrence of... 149
- Bismuth mine, ore deposits of... 175
- Blakes Camp, ore deposits at... 49, 110
  - rocks near... 106, 107
- Borax, occurrence of... 197, 201, 212
- Boundary Canyon, fossils from... 165
  - rocks in... 167
- Breen Creek, description of... 18-19
  - ore deposits on... 109
- Bullfrog, description of... 25
  - rocks at and near... 35, 178
- Bullfrog-George prospect ore deposits of. 194-195
- Bullfrog Hills, economic geology of... 182
  - geology of... 27-29, 32, 33, 41, 105, 106, 176-181
  - structure of... 181
  - topography of... 176
- Butler, J. L., discoveries by... 81

C.

- Cactus and Kawich ranges, hills between, geology of... 96-97
  - topography of... 96
- Cactus Flat, description of... 98
- Cactus Mining Company, property of... 95
- Cactus Range, economic geology of... 95-96
  - geology of... 29-33, 42, 47-48, 89-94, 104, 105, 106
  - structure of... 84-85
  - topography of... 89
- Cactus Spring, description of... 89
  - ore deposits at... 46
  - rocks near... 92-93, 95, 96
- Calico Hills, rocks in... 48, 146 147
- Cambrian rocks, deposition of... 39-40
  - occurrence and character of... 28, 51-52, 56-57, 59, 66, 72, 77-78, 84, 141, 164, 183-184, 191-192
  - ores in... 81, 82
  - structure of... 54, 62-63, 68-69, 80-81, 87-88, 149, 187, 194
- Campbell, M. R., on Death Valley... 196
  - work of... 15
- Cane Spring, flow of... 142

Page.
Cane Spring, rocks near.............. 143–146, 149
Captain Jack Spring, flow of.............. 119
Carboniferous rocks, occurrence and character of.............. 30
Cave Rock Spring, rocks near.............. 164–165
Central mine, description of.............. 188
Chapman, R. H., work of.............. 13, 58
Chief Kawich mine, description of.............. 112–113
Childers, E. A., work of.............. 13
Chloride Cliff, ore deposits at.............. 45, 46, 173–175
  rocks near.............. 161, 162
  springs near.............. 162
Chonetes permianus, occurrence of.............. 122
  sp., occurrence of.............. 122
Cladopora, occurrence of.............. 165
Cliff Spring, rocks near.............. 126
  water from.............. 113, 119
Climate, description of.............. 17
Colemanite, occurrence of.............. 197, 201
Columnar section of rocks of area.............. 27
Combination Mines Company, water supply of.............. 19
Contact veins, ore deposits in.............. 46, 49, 81–82
Copper, occurrence of.............. 130
Corral Spring, flow of.............. 100
Cottonwood Creek, description of.............. 19
  rocks on.............. 209, 211
Court, J. G., discoveries by.............. 81
Cow Creek, water of.............. 197
Crinoids, occurrence of.............. 204
Crystal Spring, flow of.............. 176
  rocks near.............. 182
Culture, description of.............. 24–26
Cuprite district, ore deposits in.............. 46, 69–71
Currie Well, rocks near.............. 171, 176, 182

D.

Dacite, definition of.............. 37
  occurrence and character of.............. 32, 34, 61–62, 73, 106–107, 181
Daggett, rocks near.............. 33
Daylight Spring, flow of.............. 162
  rocks near.............. 165–168, 171, 172, 176
Death Valley, depth to water in.............. 21
  economic geology of.............. 201
  elevation of.............. 16, 196
  formation of.............. 41
  geologic history of.............. 200–201
  geology of.............. 32, 36, 197–200
  section of.............. 199
    figure showing.............. 198
  soil from, analysis of.............. 197
  topography of.............. 195–197
  view in.............. 36
Decillion claim, description of.............. 156–157
Derbya sp., occurrence of.............. 122
Devonian rocks, occurrence of.............. 294
Devonian time, history in.............. 39
Dikes, occurrence and character of.............. 31, 33, 52–54, 58–59
Diorite, definition of.............. 37
  occurrence and character of.............. 31, 53–54
Diorite porphyry, definition of.............. 37
  occurrence and character of.............. 53–54, 60–61, 67, 91, 103, 156, 167, 179, 186, 193, 208–209
Drainage, description of.............. 16, 17, 18–19

E. Page.

Eccyliopterus sp., occurrence of.............. 155, 203
Echo Canyon, mines of.............. 175
Economic conditions, description of.............. 43–44
Economic geology, description of.............. 42–50, 54–55, 63–65, 69–71, 76, 81–83, 88–89
Eden, ore deposits at.............. 46, 110–111
Electricity, use of.............. 43–44
Emigrant Spring, flow of.............. 202
  rocks near.............. 204
Emigrant Wash, rocks near.............. 204, 209
Emmons, W. H. work of.............. 15, 71, 181
Erosion, history of.............. 40, 41–42
Eureka district, Nev., rocks of.............. 28–29
Eureka quartzite, occurrence and character of.............. 29, 90, 96, 100–102, 155, 177–178

F.

Fault zones, ore deposits in.............. 49
Faulting, occurrence of.............. 39–42
Fenestella sp., occurrence of.............. 122, 204
Florida-Goldfield Mining Company, property of.............. 64
Fortymile Canyon, rocks near.............. 133
Funeral Mountains, location of.............. 160
  rocks of.............. 116
Furnace Creek, rocks on.............. 160
  soil near, analysis of.............. 197
Fusulina sp., occurrence of.............. 122, 204

G.

Gabbard, John, discovery by.............. 138
Ganey, G. H., work of.............. 15, 71, 177, 181
General Thomas Camp, rocks at.............. 51–55
General Thomas mine, ores of.............. 46, 54–55
Geography. *See* Topography.
Geologic history, account of.............. 38–42
Geologic map of altered Tertiary rocks.............. 43
  of southwestern Missouri and eastern California.............. 26
Geology, description of.............. 26–42
Geology, economic, account of.............. 42–50, 54–55, 63–65, 69–71, 76, 81–83, 88–89, 94–95, 108–113, 117, 128–131, 137–140, 142, 147, 150, 152, 156–157, 173–176, 182, 187–191, 194–195, 201, 211–212
Geology, descriptive, by districts, account.............. 50–212
Georges Water, location of.............. 19
Gila mine, description of.............. 117
Gilbert, G. K., fossils determined by.............. 165
  reconnaissance by.............. 15
Girty, G. H., fossils determined by.............. 115, 122, 204
Girvanella, occurrence of.............. 57, 66, 120
Gold Bar mine, rocks near.............. 178
Gold Center, location of.............. 25
  water near.............. 131
  rocks near.............. 178
Gold Crater, ore deposits at.............. 46, 113, 139–140
  rocks at.............. 135
Gold Crest Mining Company, property of.............. 189–190
Gold Flat, description of.............. 98–99
Gold Mountain, economic geology of.............. 187–191
  geology of.............. 28, 30–32, 183–187
  structure of.............. 187
  topography of.............. 182–183
Gold Mountain mining district, development in.............. 187

Page.

- Gold Reed Mining Company, property of.... 111-112
- Goldbelt, ore deposits at.... 44, 211
- Goldbelt Spring, rocks near.... 203, 204
- Goldfield, ancient lake near.... 41
  - description of.... 25
  - region near, descriptive geology of.... 50-89
  - wells at.... 72
- Goldfield hills, economic geology of.... 76
  - geology of.... 28, 32-34, 72-76, 107
  - structure of.... 76
  - topography of.... 71-72
- Goldfield-Midway-Bullfrog Mining Company, properties of.... 69
- Gossan, occurrence of.... 49
- Granite, definition of.... 37
  - occurrence and character of.... 30-31, 52-53, 58-59, 73, 78, 98, 103, 123, 125, 133-135, 184-186, 192-193, 208
  - ore deposits in.... 44, 84-85, 90-91
  - veins in, figure showing.... 138
- Granite porphyry, definition of.... 37
  - occurrence and character of.... 58-59, 84-85, 90-91, 124-125, 167
- Grapevine Canyon, rocks in and near.... 171, 176
- Grapevine Range, location of.... 160
  - rocks of.... 103, 199
- Grapevine Springs, description of.... 20
  - rocks near.... 164, 165, 199
- Gravels, occurrence and character of.... 35-36, 133
- Great Basin, location and character of.... 16
- Ground water, level of.... 21-22
  - level of, section showing.... 21

H.

- Hague, Arnold, on Eureka district.... 28-30, 38-39
- Halfway Station, section near, figure showing.... 68
- Hamburg limestone and shale, nonoccurrence of.... 28
- Hanks, A. A., analysis by.... 19
- Happy Hooligan mine, ore deposits in.... 49, 173
  - rocks at.... 170
- Harrisburg, ore deposits at.... 211
- Heenan water, flow of.... 100
- Helicoma, occurrence of.... 203
- Hicks Hot Springs, description of.... 20
- Hillebrand, W. F., mineral determined by.... 191
- History, geologic, account of.... 38-42
- Hole in the Rock, rocks near.... 167
  - water of.... 162
- Horn Silver mine, rocks near.... 147
- Hot Springs, description of.... 19-20
- Howell ranch, rocks near.... 180, 182
- Humboldt series, correlation of.... 34
- Hydrology, account of.... 18-23
- Hyolithes americanus, occurrence of.... 66

I.

- Igneous rocks, definitions of.... 37-38
  - intrusion of.... 40-41
    - figure showing.... 27
  - occurrence and character of.... 30-34, 52-54, 58-62, 67-68, 73-76, 78-80, 84-87, 90-94, 96-98, 103-108, 116-117, 123-127, 133-137, 141, 144-147, 149, 151-152, 153, 155-156, 167-171, 178-181, 184-187, 192-194, 206-210

Page.

- Indian Pass, rocks at.... 161
- Indian ranch, rocks near.... 178
- Indian Spring, flow of.... 119, 176
  - rocks near.... 181
- Industries, character of.... 24-25
- Iron ores, character and distribution of.... 82

J.

- Jackson, Mount, economic geology of.... 69-71
  - geology of.... 28, 31, 66-68
  - section across, figure showing.... 68
  - structure of.... 68-69
    - section showing.... 68
  - topography of.... 66
- Jarboe Spring, flow of.... 100
- Johnnie mine, character of.... 150

K.

- Kankakee Mining Company, property of.... 82
- Kawich, character of.... 25
  - ore deposits at.... 46, 111-113
  - rocks near.... 102-104, 108
  - section near, figure showing.... 108
- Kawich and Cactus ranges, hills between. *See* Cactus and Kawich ranges.
- Kawich Peak, elevation of.... 16
- Kawich Range, economic geology of.... 108-113
  - geology of.... 29, 32, 33, 41, 42, 50, 100-107, 116
  - prospecting on.... 113
  - section across, figure showing.... 108
  - structure of.... 108
  - timber on.... 100
  - topography of.... 16, 99-100
- Kawich Valley, rocks in.... 108, 114
- Keane Spring, flow of.... 162
  - rocks near.... 164-165
  - water from.... 174
- Keane Wonder mine, ore deposits of.... 174
- King, Clarence, on geology of region.... 38, 39-40
- Kismet Mining Company, property of.... 157
- Klondike well, description of.... 77, 82
- Knowlton, F. H., fossils determined by.... 58, 132

L.

- Latite, definition of.... 37
  - occurrence and character of.... 32, 34, 73-74, 79, 80, 91-92, 105, 151, 170-171
- Leda sp., occurrence of.... 122
- Lee's Camp, ore deposits of.... 175
  - rocks near.... 162
- Lida, character of.... 25
  - ore deposits at.... 45, 64-65
  - rocks near.... 31, 57, 60, 62
- Lida-Goldfield Valley, description of.... 65
- Lige Harris prospect, description of.... 157
- Lime, occurrence and character of.... 65
- Lime Point, ore deposits at.... 44
- Limestone, ore deposits in.... 44-46, 81
- Literature, list of.... 15-16
- Little Mill Creek, description of.... 99
  - ore deposits on.... 110
- Location of district, map showing.... 14
- Lone Mountain foothills, economic geology of.... 54-55
  - geology of.... 28, 31, 51-54
  - ore deposits on.... 46
  - structure of.... 54

Page.

Lone Mountain foothills, topography of.... 51
Lone Mountain limestone, occurrence and character of............ 29,102,165,178
Longstreets Ranch Spring, flow of......... 100
Lost Wagons, rocks near.................. 207

M.

McDonald Spring, rocks near............... 176
Map, geologic, of altered Tertiary rocks.... 43
  of southwestern Nevada and eastern California...................... 26
    accuracy of........................ 13
Map, index, showing area described........ 14
Map, topographic, description of........... 14
Marble Canyon, description of............ 201-202
  view of............................... 200
Marginifera sp., occurrence of............. 122
Mesquite Flat, location of................. 196
Mesquite Spring, water of.................. 197
Metamorphic rocks, occurrence and character of......................... 132
Mexican Camp, rocks near............... 167,176
Mica schists, occurrence and character of... 132
Mining, development of.................... 42
Mohave Desert, rocks of................... 33
Monitor Hills, geology of............ 33,34,97-98
  structure of........................... 98
Monte Cristo Springs, rocks near........... 142
  water of.............................. 141
Montezuma district, ore deposits of.. 45,46,63-64
Montezuma Peak, rocks of.......... 55-58,61-65
Monzonite, definition of.................. 37-38
  limestone near, view of................ 200
  occurrence and description of.......... 32, 123,133,205-207
Monzonite porphyry, definition of.......... 38
  occurrence and character of........... 58-60, 85,103-104,144-145,184,193,205,208
  ore deposits in......................... 46
Mud Spring, flow of...................... 176

N.

New Reveille, location of.................. 117
  ore deposits and rocks at............ 115,117

O.

Oak Spring, flow of.................... 119,130
  ore deposits at................. 44,45,128-130
  rocks near................... 122,123,125,128
  section at............................ 122
Oak Spring Butte, rocks of.............. 118,127
  section through, figure showing........ 127
Oasis Valley, rocks in..................... 36
O'Briens Camp. *See* Wellington.
Old Camp, ore deposits at............ 44,188-189
Olenellus gilberti, occurrence of........... 66
Ordovician rocks, deposition of............ 38-39
  occurrence and character of........... 28-29
Ore deposits, character of................ 44-49
Oriental Wash, ore deposits at........ 45,190-191
Orthoceras olorus......................... 165
  perroti................................ 165
Orthoclase, description of................. 37
Ouida claim, ore deposits of............... 189

P.

Pahute Lake, deposition in................. 41
Pahute Mesa, economic geology of........ 137-140
Pahute Mesa, geology of....... 30,32,123,131-137
  ranges north of, descriptive geology of.. 89-131
  ranges southeast of, descriptive geology of........................ 142-157
  structure of........................... 137
  topography of.......................... 131
  view of............................... 36
Palæodictyon, occurrence of................ 121
Paleozoic sediments, ore deposits in......... 44-46
Panamint Range, economic geology of.... 211-212
  geologic history of..................... 200
  geology of............... 27,29-33,120,202-210
  structure of........................... 210
  topography of........................ 201-202
Pegmatite, definition of................... 38
  dikes of, ore in........................ 44
  occurrence and character of............ 151, 155-156,178-179
Pennsylvanian limestone, fossils from...... 122
  occurrence and character of............ 115, 118,121-122,143,203-204
Phillipsia sp., occurrence of............... 122
Pillar Spring, water of.................... 131
Plagioclase, description of................. 37
Playa deposits, occurrence and character of. 36
Pleistocene rocks, occurrence and character of................................ 35-36
Pogonip limestone, occurrence and character of.................. 28-29,89-90, 100-102,118-120,155,164-165,202-203
  structure of........................... 128
  view of............................... 200
Point of Rocks, rocks near............... 148,149
Poison Spring, rocks near............ 163,167,175
Preble Mountain, rocks near................ 76
Precipitation, records of................... 17
Productus cora, occurrence of.............. 122
  nevadensis, occurrence of.............. 122
  semireticulatus, occurrence of.......... 122
  sp., occurrence of...................... 122
Prospect Mountain limestone, occurrence and description of......... 28,148-149
Prospect Mountain quartzite, correlation of 28
  occurrence and description of.......... 25-26, 38,148,162-164,202
Prospecting, aids to...................... 49-50

Q.

Quartz Mountain, economic geology of..... 142
  geology of........................... 137,141
  structure of........................... 142
  topography of.......................... 141
Quartz Mountain Camp, rocks at........... 142
Quartz veins, ore deposits in..... 44-45,66,81,138
  ore deposits in, figure showing......... 138
Quartzite, occurrence of................... 132
Quartzite Mountain, elevation of........... 99
  rocks on......................... 100-102,113
  section of............................. 108

R.

Railroads, access by....................... 26
Ralston Valley, description of.............. 83
Ramsay well, description of................ 77
Randsburg district, rocks of................ 33
Ransome, F. L., on Happy Hooligan mine. 170
  work of......................... 13,15,71,181

Page.
Rattlesnake mine, rocks near ... 186
Recent rocks, occurrence and character of .. 33, 71
Recent time, erosion in ... 42
Receptaculites sp., occurrence of ... 203
Relief, description of ... 16-17
Replacement deposits, occurrence and character of ... 46
Reveille, ore deposits and rocks at ... 115, 117
Reveille Peak, altitude of ... 115
rocks near ... 116-117
Reveille Range, economic geology of ... 117
geology of ... 30, 32, 42, 103, 105, 115-117
section across, figure showing ... 117
structure of ... 117
topography of ... 114-115
Reveille Valley, description of ... 114
rocks in ... 104, 114
section across, figure showing ... 114
Rhombopora sp., occurrence of ... 122
Rhyolite, definition of ... 38
flow folds in, figure showing ... 68
occurrence and description of 25, 32-33, 61-62, 67-68, 72, 73-76, 78-79, 80, 85-87, 92-94, 98, 104-105, 107, 116, 125-127, 131, 135-137, 141, 145-146, 150, 151, 153, 156, 168-171, 180, 186, 193-194
ore deposits in ... 46-49
Roads, character of ... 26
Rose Spring, flow of ... 100
rocks near ... 102, 104-108
Rose's Well, rocks near ... 152
Ruiz Well, water of ... 197

S.

Salt Creek, description of ... 19
rocks on ... 199
soil near ... 196
Salt Creek Wells, water of ... 197
Sand dunes, occurrence and character of ... 36
Sand Spring, water of ... 183
Sarcobatus Flat, depth to water on ... 21, 158
description of ... 157-158
economic geology of ... 158
section across, figure showing ... 21
Schaller, Waldemar, minerals determined by ... 129-130
Schists, occurrence and character of ... 177
Secret Canyon shale, nonoccurrence of ... 28
Sedimentary rocks, columnar section showing ... 27
occurrence and character of ... 26, 35, 51-52, 56-58, 66-67, 72, 77-78, 84, 89-90, 96, 97, 100-103, 115, 119-123, 132-133, 141, 143-144, 148-149, 154-155, 162-167, 177-178, 183-184, 191-192, 197-200, 202-205
Seminula sp., occurrence of ... 122
Shale Peak, rocks of ... 169
Shoshone Mountain, economic geology of ... 147
geology of ... 30, 32, 33, 48, 104, 123, 143-147
section on ... 143
structure of ... 147
topography of ... 142-143
Siebert lake beds, correlation of ... 33
deposition of ... 41
occurrence and character of ... 31-33, 48, 57-58, 67, 72, 77, 78, 84, 98, 102-103, 122-123, 132, 143, 165-166, 178, 198-199
Silent Canyon, rocks of ... 136
Silurian rocks, occurrence and character of. 28-29
Silver Peak quadrangle, rocks of ... 51
Silver Peak Range, northeast extension of, economic geology of ... 63-65
northeast extension of, geology of ... 28, 31-33, 48, 56-62, 120
structure of ... 62-63
topography of ... 55-56
Silverbow, character of ... 25
ore deposits at ... 46, 109-110
rocks near ... 47, 103, 106
Skeleton Hills, economic geology of ... 150
geology of ... 148-149
structure of ... 149
topography of ... 147-148
Skull Mountain, economic geology of ... 147
geology of ... 32, 33, 104, 143-147
structure of ... 147
topography of ... 142-143
Slate Ridge, economic geology of ... 194-195
geology of ... 28, 31, 32, 191-194
structure of ... 194
topography of ... 191
valley near, description of ... 71
Snow, occurrence of ... 22
Southern Klondike, ore deposits at ... 44-46, 49
Southern Klondike hills, economic geology of ... 81-82
geology of ... 28, 32, 33, 48, 77
ores of, value of ... 81
structure of ... 80-81
topography of ... 77
Spaulding, T. C., on geology of region ... 96, 102
work of ... 13, 203
Specter Range, economic geology of ... 150
geology in ... 26-28, 32, 38, 148-149
section of, figure showing ... 149
structure of ... 149
topography of ... 147-148
Spring Mountain Range, extension of ... 147
Springs, occurrence and description of ... 18, 19-21, 56
Spurr, J. E., on geology of region ... 33, 34, 39, 57, 68, 82, 102-103
work of ... 15
Stage lines, access by ... 26
Staininger ranch, ore deposits near ... 175
rocks at and near ... 164-165, 170
section at ... 166
springs on ... 19, 20
Stateline Mill, rocks near ... 191, 194
Stenopora carbonaria, occurrence of ... 122
sp., occurrence of ... 122
Stewart, B. D., work of ... 13, 132
Stinking Spring, flow of ... 100
rocks at ... 105
Stonewall Flat, description of ... 83
Stonewall Mountain, economic geology of. 46-47, 88-89
geology of ... 28, 32, 33, 48, 84-87, 104, 136
section across ... 133
figure showing ... 88
structure of ... 87-88
topography of ... 83-84
Stonewall Spring, section through, figure showing ... 88

Page.
Stonewall Spring, water from 71
Stovepipe Wells, section near 199
  water of 197
Stratigraphy, columnar section showing 27
  description of 26-35
Streams, description of 18-19
Structure. *See particular districts.*
Sulphur, occurrence and character of 71
Sumner Spring, flow of 100
  rocks near 103, 106, 114
Surveyors Well, rocks near 166, 199
  water of 197
Syenite, definition of 38
  occurrence and character of 85-86, 207-208

T.

Tanks, character of 21
Telescope Peak, altitude of 201
Temperature, records of 17
Tertiary rocks, areas of, economic map showing 43
  occurrence and character of 31-34
  ore deposits in 46
Tertiary time, history in 40-41
Thimble Peak, rocks of 161
Thirsty Canyon, rocks near 136, 137
Thorp, character of 25
Timber, character and distribution of 23-24, 100, 119, 162, 183, 202
Timber Mountain, geology of 32, 137, 153
  topography of 153
Tin Mountain, altitude of 201
  rocks near 202, 204, 207
Tippipah Spring, flow of 142
  rocks near 121, 122, 143, 146-147
Titus Canyon, rocks of 164, 175
Tokop, ore deposits at 189-190
  wells near 183
Tolicha Peak, economic geology of 142
  geology of 28, 32, 132, 135, 137, 141
  structure of 142
  topography of 141
Tonopah, description of 25
Topography, description of 16-17
  See also particular districts.
Topopah Spring, flow of 142
Towns, character of 25-26
Trails, character of 26
Trappman, Hermann, discoveries by 138
Trappmans Camp, ore deposits at 44, 138-139
  ore deposits at, figure showing 138
  rocks at and near 27, 28, 132, 133-135
Travertine, occurrence and character of 58
Triangle Spring, rocks near 199

Page.
Triangle Spring, water of 197
Tri-Metallic Mining Company, properties of 69-70
Trio mine, ore deposits of 174
Tucki Mountain, ore deposits of 211
  rocks near 204
Tuffs, occurrence and character of 32, 72, 132-133, 192
Turner, H. W., on climate of district 17
  on geology of district 51-52, 57
  work of 15
Turquoise, occurrence of 129-130
Twin Peaks, rocks on 113

U.

Ulrich, E. O., fossils determined by 57, 66, 120, 121, 149, 155, 165, 203
  on geology of region 66

V.

Valleys, formation of 17
Vegetation, character of 23-24

W.

Wahguyhe Peak, altitude of 161
  rocks of 168-169
Walcott, C. D., fossils determined by 57
Water, occurrence of, signs of 22-23
Weber conglomerate, correlation of 30
  occurrence and character of 30, 90, 118, 120-121
Weeks, F. B., fossils determined by 165
Wellington, ore deposits at 46, 95
  rocks at 48
Wells, occurrence and character of 21-22
Wheelbarrow Peak, altitude of 118
  rocks on and near 119, 122, 125
  section near, figure showing 119
Wheelbarrow Spring, flow of 119
Whiterock Spring, flow of 119
  rocks near 122, 127, 133-134, 140
Wild Horse Spring, flow of 100
Willow Springs, flow of 162
  rocks near 165-168
Wilsons Camp, ore deposits at 46, 139
  rocks at 48, 135-136

Y.

Yucca Mountain, economic geology of 152
  geology of 32, 150-152
  structure of 152
  topography of 150
Yucca Pass, rocks near 145-146

Z.

Zaphrentis sp., occurrence of 122

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[Bulletin No. 308.]

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DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY
CHARLES D. WALCOTT, DIRECTOR

THE
SANTA CLARA VALLEY, PUENTE HILLS AND LOS ANGELES OIL DISTRICTS
SOUTHERN CALIFORNIA

BY
GEORGE HOMANS ELDRIDGE
AND
RALPH ARNOLD

WASHINGTON
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1907

CONTENTS.

Page.

PREFACE XI

THE SANTA CLARA VALLEY OIL DISTRICT, SOUTHERN CALIFORNIA, BY GEORGE H. ELDRIDGE.

Introduction 1
Acknowledgments 1
Topography 1
Geologic formations 4
  General statement 4
  Granitic basement 5
    General character and distribution 5
  Topatopa formation 5
    General character 5
    Distribution 7
    Age 7
    Occurrence of oil 7
  Sespe formation 7
    General character 7
    Lower zone 8
    Red beds 8
      General description 8
      In the Ojai Valley 9
      South of the Santa Clara 10
      Oil in the red beds 10
    Upper zone 10
      Relation of upper Sespe beds to Vaqueros shale 11
      Oil in the upper Sespe beds 12
  Vaqueros formation 12
    Age and general character 12
    In the Ojai Valley 13
    South of the Santa Clara 15
  Modelo formation 17
    General character 17
    Lower sandstone 18
    Upper sandstone 18
    Shale in the Modelo 19
    Variation in composition of the Modelo 19
    Supposed Modelo beds in the Ojai Valley and Sulphur Mountain 20
    Correlation of the upper shaly portion of the Modelo with the Monterey shale 20
    Difficulties of correlation between north and south sides of Santa Clara Valley 21
    Burning of the shale 22

Geologic formations—Continued.

Page.
- Fernando formation 22
  - General character and age 22
  - Paleontology of the Fernando formation 23
    - Lower Fernando fauna 24
    - Middle Fernando fauna 25
    - Upper Fernando fauna 25
- Pleistocene deposits 28
  - In the vicinity of Saugus 28
  - At mouth of Sespe Canyon 28
  - Conglomerate of Lion Canyon 28

General structure of district 29
- Introductory statement 29
- Santa Clara Valley 29
- Region north of the Santa Clara 30
- Region south of the Santa Clara 35

Oil fields north of the Santa Clara 36
- Ojai Valley fields 36
  - Location 36
  - Structure 36
  - Oil wells 39
    - Pirie ranch wells 39
    - Lion Canyon wells 40
    - Langdell, Newmark & Roan wells 40
    - Whidden-Double wells 40
    - Sobra Vista wells 41
    - Santa Paula wells 42
- Southern Sulphur Mountain field 42
  - Location 42
  - Geology 42
  - Structure 44
  - Oil wells 45
- Silver Thread or Sisar Creek field 46
  - Location 46
  - Structure 46
  - Oil wells 48
- Field south of Santa Paula Ridge 49
  - Location 49
  - Geology and structure 49
  - Oil wells 50
- Sespe fields 51
  - Location 51
  - Structure 51
  - Oil wells 54
    - Union Consolidated wells 54
    - Region of Devilsgate 54
    - Ivers wells 55
    - Kentuck wells 56
    - Happy Thought wells 58
    - Foot-of-the-Hill or Los Angeles wells 58
    - Fourfork wells 60
    - Tar Creek wells 61

Oil fields north of the Santa Clara—Continued.

Page.

- Pole Canyon 62
  - Location 62
  - Geology and structure 62
- Hopper-Piru fields 64
  - Location 64
  - Structure 64
    - West of Piru Creek 64
    - East of Piru Creek 67
  - Oil wells 68
    - San Cayetano wells 68
    - Sunset wells 69
    - Fortuna wells 69
    - Nigger Canyon wells 71
    - Modelo Canyon wells 71
    - Wells of the Piru Oil and Land Company 74
    - Wells of Holser Canyon 75

Oil fields south of the Santa Clara 76
- General statement 76
- Bardsdale field 76
  - Location 76
  - Geology and structure 76
  - Oil wells 79
    - Union and Bardsdale crude wells 79
- Torrey-Eureka-Tapo fields 80
  - Location 80
  - Geology and structure 80
  - Oil wells 86
    - Torrey wells 87
    - Eureka wells 87
    - Tapo wells 89
- Pico fields 90
  - Location 90
  - Geology and structure 90
  - Productive fields of the Pico district 93
  - Oil wells 94
    - Pico Canyon wells 94
    - Dewitt Canyon wells 95
    - Towsley Canyon wells 95
    - Wiley Canyon wells 96
    - Rice Canyon wells 96
    - East Canyon wells 96
- Elsmere field 96
  - Location 96
  - Geology and structure 97
  - Oil wells 98
    - Enterprise, Pearl, and Zenith wells 98
    - Elsmere Ridge wells 99
    - Elsmere Canyon wells 99
    - Nettleton & Kellerman wells 99
    - Well south of ridge crest 99
    - Placerita Canyon wells 100

THE PUENTE HILLS OIL DISTRICT, SOUTHERN CALIFORNIA, BY GEORGE H. ELDRIDGE.

Page.

Introduction 102
Acknowledgments 102
Location and topography 102
Geology 103
  Formations 103
  Lower Puente shale 103
  Puente sandstone 104
  Upper Puente shale 104
  Correlation of the Puente formation with the Monterey 105
  Post-Puente diabase 106
  Fernando formation 106
  Pleistocene 107
Structure 108
  General structural relations of the fields 108
  Coyote Hills anticline 109
Geologic relations of oil-bearing strata 109
Oil fields 110
  Whittier field 110
    Location 110
    Geology 110
    Structure 112
    Oil wells 113
  La Habra Canyon field 115
    Location 115
    Geology 115
    Structure 116
    Oil wells 117
  Puente field 117
    Location 117
    Geology 117
    Structure 118
    Oil wells 119
  Brea Canyon field 120
    Location 120
    Geology 120
    Structure 121
    Oil wells 123
  Olinda field 125
    Location 125
    Geology 125
    Structure 126
    Oil wells 131
  Chino field 132
Conclusions concerning future development 132
Petroleum of the Puente Hills district 133
  Yield and gravity of oil in different fields 133
  Factors in yield of wells 133
  Associated hydrocarbons 134
  Storage and transportation 134
  Utilization of the oil 135
  Production 136
  Prices 136
Oil companies in Puente Hills district 137

THE LOS ANGELES OIL DISTRICT, SOUTHERN CALIFORNIA, BY RALPH ARNOLD.

Page.
Introduction........ 138
Acknowledgments........ 138
Previous knowledge of the region........ 138
Location and topography........ 142
Geologic formations........ 143
  General statement........ 144
  Black schist........ 145
  Granite........ 145
  Puente sandstone........ 145
    General character........ 145
    Fossils........ 146
  Upper Puente shale........ 148
    General character........ 148
    Oil sands........ 149
  Miocene basalt........ 150
  Fernando formation........ 150
    General character........ 150
    Fossils........ 152
  Pleistocene........ 153
    General character........ 153
    Brea deposits........ 154
Structure........ 155
  General features........ 155
  Structure of the oil belt........ 156
  Joint cracks........ 157
Oil fields........ 158
  Location........ 158
  Development........ 158
  Eastern field........ 160
    Location........ 160
    Topography........ 160
    Geology........ 160
    Geology of the wells........ 162
    Structure........ 163
    Development........ 164
  Central field........ 165
    Location........ 165
    Topography........ 165
    Geology........ 165
    Geology of the wells........ 167
    Structure........ 170
    Development........ 172
  Western field........ 172
    Location........ 172
    Topography........ 172
    Geology........ 173
    Geology of the wells........ 174
      Baptist College area........ 175
      Vicinity of Western avenue and Temple road........ 178
      Area one-fourth mile northwest of Temple road and Western avenue........ 181
      Area south of Colegrove........ 182
    Structure........ 184

Oil fields—Continued. Page.
- Salt Lake field 186
  - Location 186
  - Geology 186
    - General statement 186
    - Oil sands 186
    - Brea deposits 187
  - Geology of the wells 187
    - Area north and northwest of the lagoon 187
    - Area south and southeast of the lagoon 191
  - Structure 193
  - Development 195

Conclusions concerning future development 196
- City fields 196
- East of Los Angeles River 196
- Southwest and west of Los Angeles 197

Production 198
Storage 198
Transportation 198

BIBLIOGRAPHY OF SOUTHERN CALIFORNIA OILS 199

PHYSICAL AND CHEMICAL PROPERTIES OF SOUTHERN CALIFORNIA OILS,
COMPILED BY RALPH ARNOLD.

Introduction 203
General character of the southern California oils 203
- Gravity 203
- Color 203
- Composition 204
- Fuel and gas making 204
- Products of refineries 205

Analyses 205

FOSSILS OF THE OIL-BEARING FORMATIONS OF SOUTHERN CALIFORNIA,
BY RALPH ARNOLD.

Introduction 219
Plates 221

INDEX 259

ILLUSTRATIONS.

Page.

PLATE I. Geologic map of Santa Clara Valley and adjacent oil fields in Ventura and Los Angeles counties.............................. Pocket.
II. *A*, View across Hopper Canyon to valley of Piru River; *B*, The great Topatopa anticline, Sespe oil field.................... 2
III. Geologic structure sections across Mount Pinos, Tejon, Santa Paula, and Camulos quadrangles.................................. 28
IV. Geologic structure sections across Camulos, Santa Susana, and Fernando quadrangles.. 30
V. Township and section map of the Santa Clara district, showing location of oil wells...................................... 36
VI. *A*, Flanks of Oak Ridge and the Santa Susana Mountains, showing post-Pliocene peneplain; *B*, The Upper Ojai Valley........ 46
VII. *A*, Santa Paula Canyon; *B*, Elsmere Hill and oil wells, near Newhall, Los Angeles County.................................. 48
VIII. *A*, Modelo wells, Modelo Canyon, Ventura County; *B*, Fortuna wells, Hopper Canyon, Ventura County......................... 70
IX. *A*, Overturn in Vaqueros formation, west side of Pico Canyon, Los Angeles County; *B*, Pico anticline, Pico Canyon, Los Angeles County... 90
X. Geologic map of the oil fields of Puente Hills.................... 102
XI. Geologic sections across the oil fields of the Puente Hills district.. 108
XII. Township and section map of the Puente Hills oil district, showing location of oil wells...................................... 110
XIII. *A*, Wells along Central Oil Company—Murphy Oil Company property line, Whittier field, Los Angeles County; *B*, Productive well in vertical strata, Whittier field, Los Angeles County...... 112
XIV. *A*, Brea Canyon field, Orange County; *B*, Characteristic pumping plant, Whittier field, Los Angeles County..................... 120
XV. *A* and *B*, Panorama of the Olinda oil field...................... 124
XVI. Detailed geologic section through Olinda oil field.................. 130
XVII. Chart showing variation in daily production of a group of oil wells in the Puente Hills district.................................. 134
XVIII. Geologic map of the region of the Los Angeles oil fields........... 144
XIX. Street and section map of the Los Angeles oil fields, showing location of oil wells... 158
XX. Geologic structure sections across Los Angeles oil fields, Los Angeles quadrangle.. 162
XXI. *A*, Nodular Miocene sandstone at Los Angeles; *B*, Typical lower Miocene sandstone at Los Angeles............................ 166
XXII. *A*, Eastern oil field, Los Angeles; *B*, Central oil field, Los Angeles. 168
XXIII. Salt Lake field, Los Angeles...................................... 186

Page.
XXIV. *A*, Characteristic thin-bedded Pliocene sandstone, Los Angeles oil fields; *B*, Lagoon in the Salt Lake field, Los Angeles, showing floating oil and bubbling water caused by escaping gas........ 188
XXV. Eocene Pelecypoda........ 223
XXVI. Eocene Pelecypoda and Gasteropoda........ 225
XXVII. Miocene Pelecypoda and Gasteropoda........ 227
XXVIII. Miocene Pelecypoda and Gasteropoda........ 229
XXIX. Miocene Echinoidea and Pelecypoda........ 231
XXX. Miocene Echinoidea, Pelecypoda, and Gasteropoda........ 233
XXXI. Miocene Pelecypoda and Gasteropoda........ 235
XXXII. Miocene Pelecypoda, Gasteropoda, and Crustacea........ 237
XXXIII. Miocene Pelecypoda and Gasteropoda........ 239
XXXIV. Pliocene pectens........ 241
XXXV. Pliocene pectens........ 243
XXXVI. Pliocene pectens........ 245
XXXVII. Pliocene arcas........ 247
XXXVIII. Pliocene Pelecypoda and Gasteropoda........ 249
XXXIX. Pliocene Brachiopoda and Pelecypoda........ 251
XL. Pliocene Pelecypoda and Gasteropoda........ 253
XLI. Tertiary turritellas........ 255
Fig. 1. Index map of portion of southern California........ 2
2. East-west section across Sespe Canyon above mouth of Tar Creek........ 8
3. North-south section, on north side of Lower Ojai Valley........ 9
4. Sketch map showing location of wells and oil seepages in the northeast corner of Upper Ojai Valley........ 41
5. Sketch map showing location of Ivers wells, with relation to anticlinical axis in the Sespe red beds........ 55
6. Sketch map showing location of Kentuck group of wells in syncline in Sespe red beds........ 57
7. Sketch map of Foot-of-the-Hills oil wells........ 59
8. Sketch map showing location of the Fourfork group of wells, with relation to the base of the upper purple beds........ 60
9. Sketch map showing location of the Fortuna wells, with relation to the anticlinal axis........ 70
10. Section through Fryers Peak east of Fryer's ranch........ 92
11. Sketch map showing location of Placerita Canyon wells, 5 miles east of Newhall........ 100
12. Generalized geologic section for the immediate vicinity of the Los Angeles oil fields........ 144
13. North-south section across the central field........ 171
14. North-south section along Hoover street, Los Angeles........ 175
15. Detail of section along line C–D, western oil field........ 178
16. Detail of section along line A–B, western oil field........ 181
17. Northwest-southeast sections in Salt Lake field........ 189

PREFACE.

Soon after Mr. Eldridge's lamented death, June 29, 1905, an examination was made of his unfinished reports on the oil fields of California to determine in what shape he left them. His field work had covered a period of approximately one year, from about July 1, 1901, to July 1, 1902. During this time he had examined all the principal oil districts from San Mateo County southward to the Santa Ana Mountains. He had planned to describe the oil fields of this entire area in one large monograph, and at the time of his death had practically completed the manuscript and accompanying geologic maps for the chapters on the Parkfield (Monterey County), Santa Clara Valley (Ventura and Los Angeles counties), and Puente Hills (Los Angeles and Orange counties) districts. Poor health for some time previous to his death precluded his doing more than this, and although there were copious notes relating to all the other districts none of these had been written up. The sad duty of preparing the nearly completed manuscript for publication and of utilizing the remaining notes for other reports was assigned to the writer.

In order to facilitate the publication of the chapters nearest completion it was deemed expedient to issue them one or more at a time as bulletins, instead of in a single monograph, as originally contemplated by Mr. Eldridge. This change in the method of publication necessitated some changes in the arrangement of the text and the treatment of the subject. In making these alterations, however, it has been the writer's sincere effort to modify as little as possible Mr. Eldridge's style of writing and manner of presentation.

The text and geologic maps of the Santa Clara Valley and Puente Hills reports are entirely the work of Mr. Eldridge, with the exception of some changes in the arrangement and some minor additions bringing them up to date. The choice and preparation of the illustrations and the preparation of the cross sections fell to the lot of the writer. The forbearance of the reader is besought for any inconsistencies or deficiencies in this bulletin, as they are doubtless largely due to the writer's inability to interpret and transcribe the ideas which Mr. Eldridge recorded in his notes.

RALPH ARNOLD.

JUNE 30, 1906.

THE SANTA CLARA VALLEY OIL DISTRICT, SOUTHERN CALIFORNIA.

By George Homans Eldridge.

INTRODUCTION.

This paper presents a brief description of the oil fields of the region adjacent to the Santa Clara Valley, in Ventura and Los Angeles counties, Cal. Owing to the somewhat limited time available for the field work it has been impossible to go into as much detail concerning certain of the fields as might be desirable. However, it is hoped that the data here brought together will be of assistance in the future development of the district. Figures of the characteristic or common fossils of the different formations of the district are given in Pls. XXV to XLI. The physical and chemical properties of the oil are treated on pages 203–218.

ACKNOWLEDGMENTS.

The writer wishes to extend his sincere thanks and acknowledgments to the officers and operators of the different oil companies in the district for their hearty cooperation and support. Without the data furnished by them the preparation of such a report as this would have been impossible.

TOPOGRAPHY.

The Santa Clara Valley of southern California is a structural depression modified by erosion. The heads of the valley lie in the San Gabriel Range and in the mountains to the north, which connect this range with other portions of the Coast Range and with the Sierras. After a westerly course of 75 miles the stream which drains the valley enters the Pacific a little south of the town of Ventura. The valley proper is given over to agriculture, but in the mountains on either side are many important oil fields.

The mountains north of the valley form the watershed between it and the Central Valley of California and also present a barrier to the Mohave Desert, which lies in the angle between the Sierras and the more southerly ranges of the State. These mountains are excessively rugged and represent the convergence of several ranges, which to the northwest maintain a conspicuous individuality. Pine Mountain, which is 7,488 feet in altitude, is their culminating point. The area thus occupied forms a part of the Santa Barbara Forest Reserve, recently set aside by the United States Government. The greater portion of it is accessible only by trail and is almost wholly uninhabited.

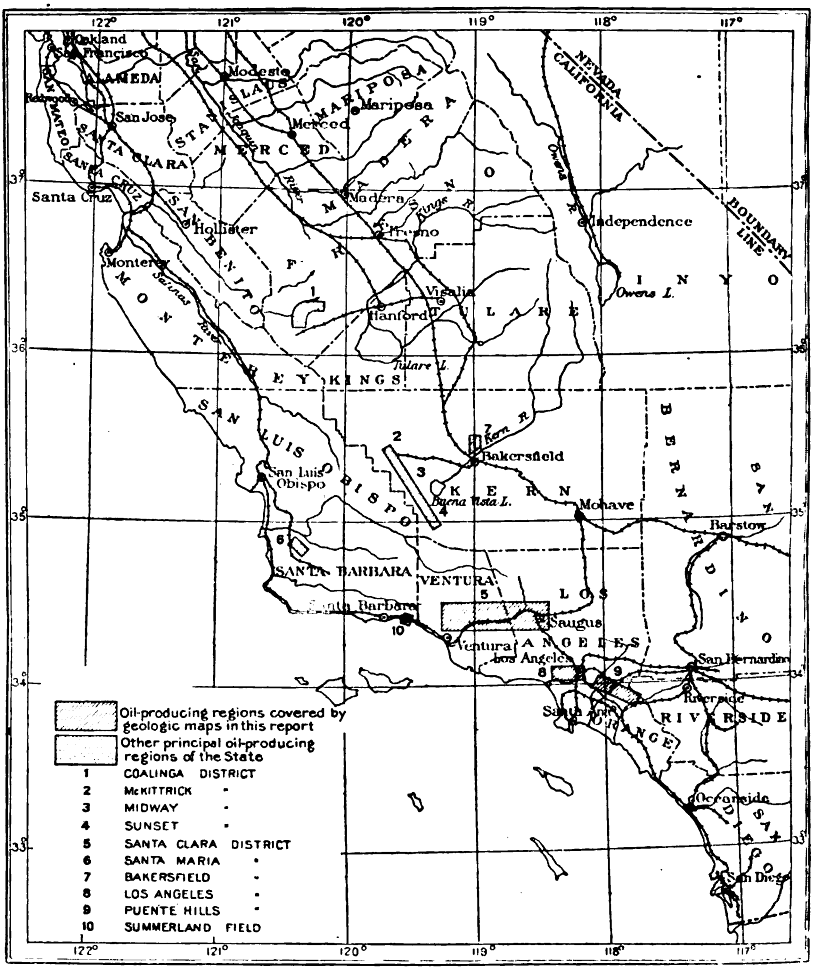
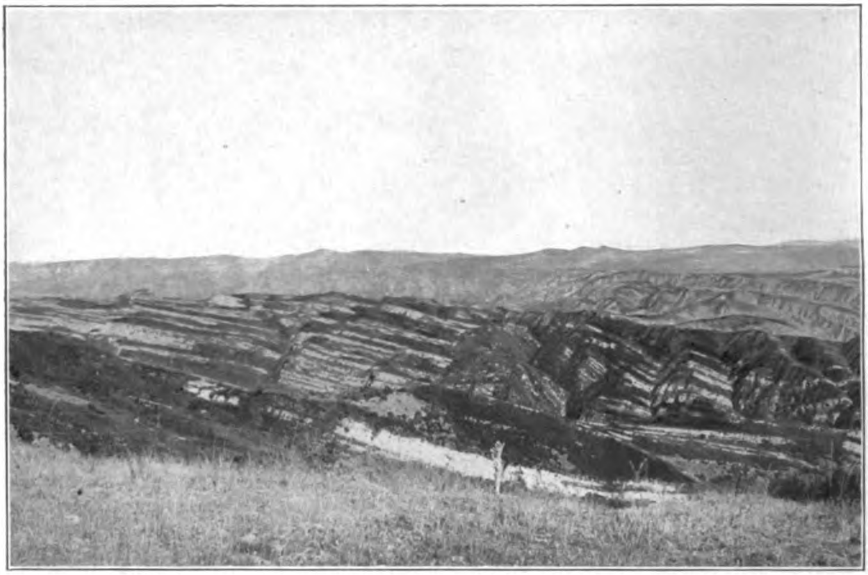


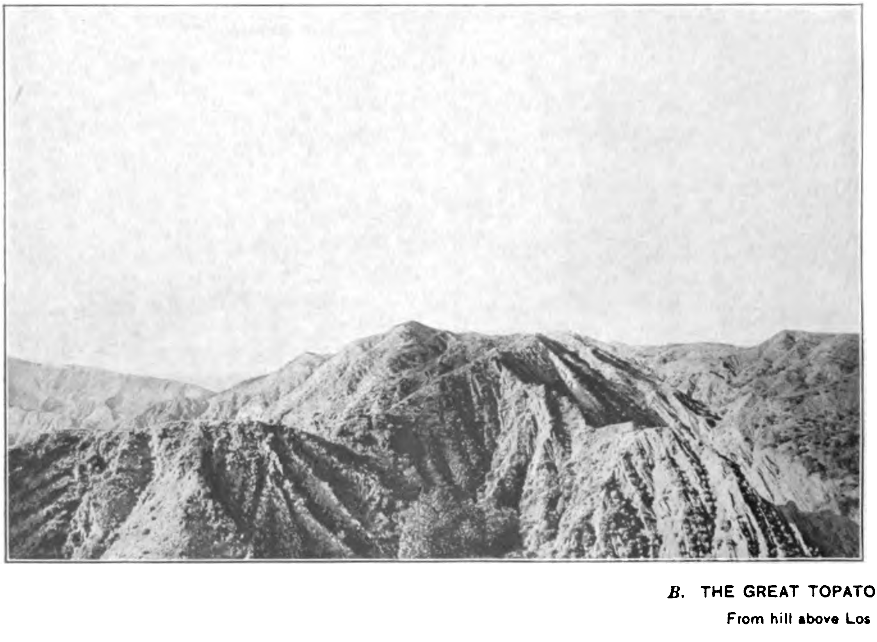
FIG. 1.—Index map of a portion of southern California, showing the location of the three districts described in this bulletin and of the other important producing districts of the State.

The San Gabriel Range, in which rise the southerly heads of Santa Clara River, equals in ruggedness and general altitude the mountains to the north. This range, with its western extension, the Santa Susana Mountains, separates the Santa Clara Valley from those of Los Angeles, Tujunga, and San Gabriel rivers, while still farther west Oak Ridge and South Mountain, in extension of the



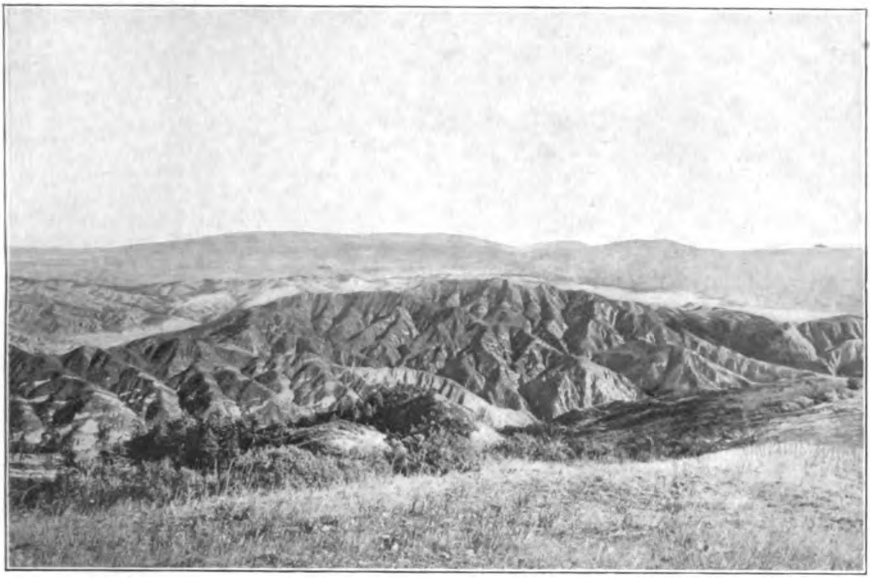
A. PANORAMA ACROSS HOPPER CA

From Hopper Peak



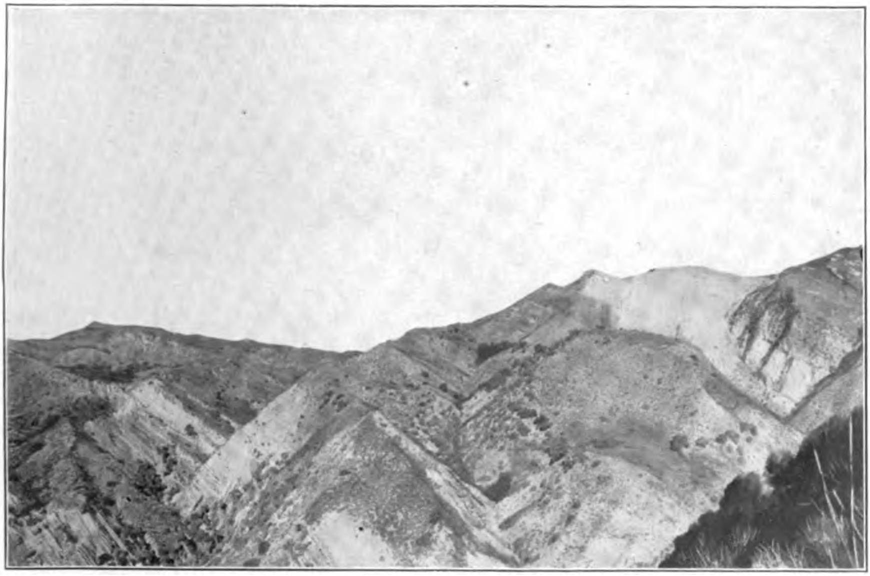
B. THE GREAT TOPATOPA A

From hill above Los Angel



ANYON TO VALLEY OF PIRU RIVER.

Ventura County.



ANTICLINE, SESPE OIL FIELD.

es wells, Ventura County.

Santa Susana Mountains, lie between this valley and the minor depression of the Simi. The San Gabriel Range attains its maximum altitude at 10,080 feet in San Antonio Peak, in the eastern portion of the uplift. The highest peak in the Santa Susana Mountains reaches 3,756 feet. Oak Ridge and South Mountain rise to maximum elevations of 3,000 and 2,258 feet, respectively.

The Santa Clara receives its principal streams from the north. Named from east to west, these are: Castac, Piru, Sespe, and Santa Paula creeks. The courses of these streams are most tortuous, their loci having been determined in part by structure, in part by erosion. Their canyons are deep, sharply cut, and in many places cliff bound and inaccessible. In addition, there is a well-distributed and dense growth of chaparral. Sespe and Santa Paula creeks carry comparatively large amounts of water throughout their length. Piru Creek is a somewhat smaller stream, but is sufficient for the irrigation of the fertile lands which border its lower course to a width of a mile or more on either side. The Castac Valley is practically dry.

The Ojai Valley, an intermontane depression which evidently had its origin in a system of profound faults, but whose aspect has since been modified by erosion of the strata over the area of excessive disturbance, lies some distance north of the lower part of the Santa Clara Valley, yet from a geologic standpoint it is a part of the general area here considered. The trend of the valley is east and west; its length is about 12 miles, and its width from 2 to 3 miles. The drainage is now chiefly to the west, San Antonio Creek flowing through it and joining Ventura River, a stream of considerable size, which flows thence 10 miles to the south, entering the Pacific at the town of Ventura, not far from the mouth of the Santa Clara. At the eastern edge of Ojai Valley, however, a minimum of the drainage passes into Sisar Creek, which discharges into Santa Paula Creek. Midway of its length a low ridge divides the depression into two parts, known as the upper and lower valleys. The altitude of the upper valley ranges from 1,250 feet at its western extremity to 1,500 feet at its eastern; that of the lower valley from 750 to 1,000 feet. Ojai Valley is well watered from natural streams and wells. A few miles up Matilija Creek are noted hot springs that are reported to have remarkable healing powers.

North of Ojai Valley is the Topatopa Range, 7,000 feet in altitude; on the south is Sulphur Mountain, 2,750 feet. The mountainous country north of the valley can be reached only by trails, and although the distance across it to the San Joaquin Valley is but 36 miles, the region is one of the least accessible in the United States. Sulphur Mountain presents a steep northern face little indented with canyons; its southern slope, however, has been severely scarred by erosion, but is traversed by canyon roads. (See Pl. II.)

The centers of settlement in the Santa Clara Valley include Ventura, Santa Paula, Fillmore, Piru, Newhall, Camulos, and Saugus, their relative importance being in the order named.

The oil fields north of the Santa Clara Valley are developed on the open slopes in front of Mount San Cayetano and in the tributary canyons to a distance into the range of 5 to 10 miles. These fields include in succession from east to west, Piru, Modelo, Nigger, Hopper, Tar, Little and Big Sespe canyons, and the San Cayetano, Silver Thread, and Ojai fields. They follow in their development the line of the higher mountains. From Santa Paula Canyon westward, however, there is a line of wells in Adams, Salt Marsh, Wheeler, and Aliso canyons, along the south side of Sulphur Mountain, in strata younger than those carrying most of the wells in the fields just referred to. Prospecting is carried on west of Aliso Canyon, even as far as the valley of Ventura River, but no productive territory has yet been found in that area.

The productive wells south of the Santa Clara Valley are confined to the northern slopes of the Santa Susana Mountains and Oak Ridge, with the exception of a single well in the canyon of Placerita Creek, a stream which drains a portion of the northwestern slope of the San Gabriel Range. The field in which this well lies is the easternmost of those developed. Next westward is the Elsmere field, a mile or two southeast of Newhall; to the southwest of Newhall, in canyons descending from the Santa Susana Mountains, are, successively, the Rice, Wiley, Towsley, Dewitt, and Pico fields, the last noted in the past, as well as at present, for the lightness of its oil and the magnitude of its production. Along the northern face of Oak Ridge, 5 or 6 miles west of the Pico field, are those lying in Tapo, Eureka, and Torrey canyons; Wiley, Garberson, Shields, Grimes, and other canyons have also been prospected, but without much success, except in the case of Grimes Canyon, west of which no developments have thus far taken place.

The railway connection for these oil fields is the Coast division of the Southern Pacific, which unites with the San Joaquin Valley division at Saugus and passes thence southward to Los Angeles, distant 33 miles.

GEOLOGIC FORMATIONS.[a]

GENERAL STATEMENT.

The formations of the Santa Clara Valley include certain Pleistocene beds of which the precise horizon is not determined; a great series of conglomerates, sandstones, and arenaceous clays which were designated by Hamlin some years since as the Fernando formation and which probably represent all of the Pliocene and overlap into both the Miocene and the Pleistocene; the Modelo formation, of sandstones and shales, which may prove to be the homologue of the Monterey; the Vaqueros formation, of shales, interbedded limestones, and sandstones; the Sespe formation, in the main a great body of brownish-red sandstones and conglomerates; the Topatopa formation, of quartzites, sandstones, and hard, more or less siliceous, and earthy shales; and an older basement of gneisses and granites, probably of Jurassic age. This series of formations appears to be conformable from the base of the Topàtopa as far up as the base of the Fernando, where a distinct chronologic break is observable. The later Pleistocene, also, is unconformable with the beds below, resting here upon one formation, there upon another.

---

[a] See p. 113 for table of tentative correlations between the oil-bearing formations of southern California.

GRANITIC BASEMENT.

GENERAL CHARACTER AND DISTRIBUTION.

The oldest rocks in the territory under discussion are the gneisses and granites which underlie the Tertiary sediments east of Newhall. The gneisses are close grained, micaceous, conspicuously banded, and greatly contorted. In the region mentioned they strike approximately N. 70° W. and dip 50°-80° N. The underlying granitic rocks are mostly medium to fine-grained diorites, similar to those lying farther east which make up a large part of the San Gabriel Range. These and the other crystalline rocks found in the San Gabriels have been described by Arnold and Strong.[a] The granitic rocks are probably contemporaneous with those of the Sierra Nevada, which are of late Jurassic age. The most remarkable thing in connection with the gneisses east of Newhall is the occurrence in them of a very light oil, approaching a naphtha. Alternative hypotheses regarding the origin of this oil are given in the discussion of the geology of the Elsmere field (pp. 100-101).

TOPATOPA FORMATION.

GENERAL CHARACTER.

The Topatopa formation receives its designation from the name of the range of which it is the chief constituent. It is the lowest formation outcropping in the mountains north of the Santa Clara Valley. Its total thickness is unknown, but about 5,500 feet are exposed. This consists of excessively hard, submassive sandstones and quartzites, the latter of a greenish-gray color, clear or mottled with white, and shales, which differ from the quartzites in carrying an additional content of mica, in the fineness of their material, and consequently in their structure. The shales are of a slightly bluish hue, but discolor a rusty brown from the presence of iron or petroleum, or both. The mottlings of the quartzites, which are very characteristic, are usually about one-fourth inch in diameter, round or irregular in outline, and in many instances are as conspicuous as the greener, more homogeneous portion of the rock. The sandstones of the formation are usually light gray to white, and are only a little less hard and close textured than the quartzites. They carry numbers of *Ostrea*, the shells of which are usually black and 4 or 5 inches long by 3 or 4 inches across. It is difficult to obtain good specimens of these fossils, and their determinative value remains for the present unknown.

---

[a] Arnold, Ralph, and Strong, A. M., Some crystalline rocks of the San Gabriel Mountains, California: Bull. Geol. Soc. America, vol. 16, 1905, pp. 183-204.

The quartzites and sandstones greatly predominate in the lower 2,000 feet of the formation as exposed, and the shales in the upper portion, but both types of rock intermingle to a considerable degree, imparting thus to the series as a whole a marked uniformity of appearance, which, with the persistency of its principal characteristics, is of especial value in identification. The formation contains toward the middle quartzites similar to those lower down.

The conspicuous features of this formation are a tendency to a broad concretionary structure in some of its members; the presence of smaller brown ferruginous sand concretions; the sparse distribution of fossil oysters and other very imperfect molluscan remains through a great portion of its thickness, more particularly in the shales; some evidences of woody tissue, and a frequent recurrence of what appear to be fucoids.

The upper part of the Topatopa formation on the lower slopes of the mountains on the north of the Ojai Valley consists of a succession of very ferruginous rusty-brown and gray sandstone and sandy shale, perhaps 2,500 feet thick in all. This facies of the Topatopa extends eastward as far as the Silver Thread field, adjoining the Ojai Valley on the east. The dip of the rusty beds at the mouth of Señor Canyon is southward, changing to northward at a point immediately within the low outer hills of the range. West of the canyon the northerly dip is maintained to a point far up the slopes. East of the canyon there are a number of flexures of greater or less severity, but of short extent. The strata are also bent at this point, the strike, which east of Sulphur Canyon is N. 60° to 70° W., west of the gorge becomes east and west, or even a little south of west, this direction being maintained to a point beyond Matilija Creek.

Cross-bedding is here and there observable. In the shaly zones there is a remarkable tendency to rapid variation in the thickness of the component layers; there also appears to be a certain amount of intraformational unconformity.

DISTRIBUTION.

The Topatopa formation occupies the heart of one of the greatest anticlines of southern California. The eastern limit of the formation is the eastern wall of Sespe Canyon. Westward it extends to a point far beyond the Ojai Valley—indeed, beyond Santa Barbara, a distance of at least 50 or 60 miles. Besides the area thus occupied there is possibly a small inlier in the heart of the Coldwater anticline (see p. 8), although the distance beneath the lower members of the Sespe formation is but slight. San Cayetano Mountain is also composed of this formation.

AGE.

Characteristic Eocene fossils have been obtained from the upper part of the Topatopa formation in the region north of the Silver Thread field. With the exception of the granite and gneisses previously described, no rocks older than the Topatopa are exposed in the Santa Clara district.

OCCURRENCE OF OIL.

The Topatopa formation is oil bearing at several horizons, and from it come seepages and sulphur springs. While these have been observed more particularly from the upper portion, they are also reported from the lowest beds exposed at the heart of the anticline.

SESPE FORMATION.

GENERAL CHARACTER.

The term Sespe has been employed[a] to designate a prominent and widely distributed mass of brownish-red sandstones and conglomerates, with minor layers of sandy and muddy shales, in all about 3,500 feet thick. With these are included 400 or 500 feet of white sandstone and greenish shale at the base and an equal amount of rust-colored calcareous sandstone at the top. The entire formation is exposed in a continuous section in the gorge of Sespe Creek near the entrance of Tar Creek and in the region which extends eastward between the waters of Tar and Little Sespe creeks. Throughout the formation the materials, whether fine or in the form of pebbles, are chiefly granitic. The coloring of the beds is in the main due to iron, but the pink feldspar adds to the effect.

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[a] Waits, W. L., Bull. California State Mining Bureau, No. 11, 1897, pp. 25-26.

LOWER ZONE.

Fig. 2 is a section of the lower 400 feet, which forms a persistent divisional zone between the Topatopa formation and the main mass of red beds. This part of the formation occurs at the mouth of a small tributary entering Sespe Creek from the slopes of Sulphur Peak at a point about a mile above the mouth of Tar Creek. It reappears 2 or 3 miles lower down Sespe Creek, in the heart of the Coldwater anticline. The distinguishing features of this zone are the whiteness of its sandstones, in contrast with the measures both above and below, and the delicate green and pink tints which pervade its clays and shales. The heaviest of the sandstones is a bed about 80 feet thick at the base. The lower half of the zone has produced oil in commercial quantities.

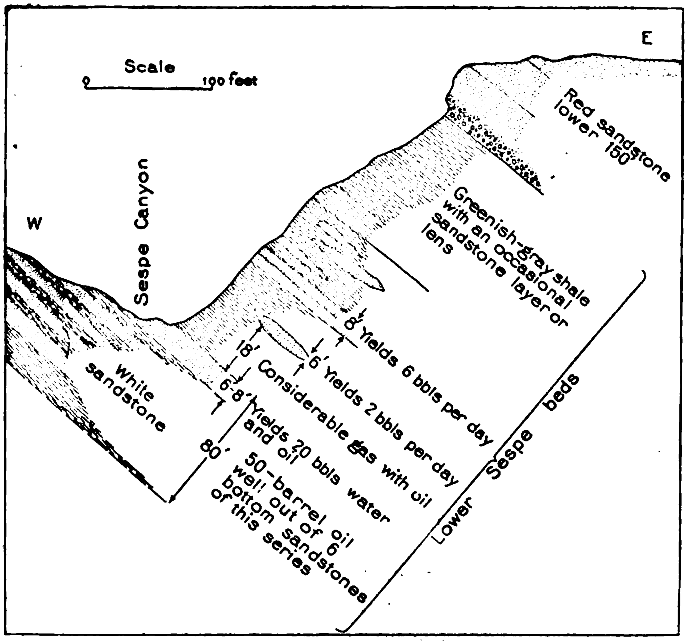
E
Scale
0 100 feet
Red sandstone lower 150'
W
Sespe Canyon
Greenish-gray shale with an occasional sandstone layer or lens
8' Yields 6 bbls per day
6' Yields 2 bbls per day
18' Considerable gas with oil
6-8' Yields 20 bbls water and oil
80' 50-barrel oil well out of 6 bottom sandstones of this series
White sandstone
Lower Sespe beds

Fig. 2.—East-west section across Sespe Canyon above mouth of Tar Creek, showing detail of the lower portion of the Sespe formation, together with its oil-bearing sands.

RED BEDS.

GENERAL DESCRIPTION.

The beds of brownish-red color which constitute the mass of the Sespe formation and overlie the lower zone present at their base a band of coarse conglomerate from 40 to 100 feet thick. Above this is 300 or 400 feet of massive sandstone, with pebbles here and there. This is overlain by approximately 500 feet of heavy sandstone, with thin bodies of shale. The material of this sandstone is in many places coarse and gritty. Still higher are from 400 to 800 feet of sandstone and shale, the latter being somewhat more prominent than lower down in the formation. While the conglomerate is principally developed as indicated, layers of comparatively coarse pebbles are not infrequently encountered from the base to the summit of the red beds. There are, however, great masses of sandstone of uniform texture and color, capable, it may be remarked incidentally, of yielding a building stone of high grade. These beds as here described maintain their principal characteristics of color, texture, and composition wherever encountered in the Topatopa Range and its subordinate ridges. They occur in the type locality of the formation and form a conspicuous feature along the northern edge of the Ojai Valley and farther west, in the vicinity of Summerland and Santa Barbara.

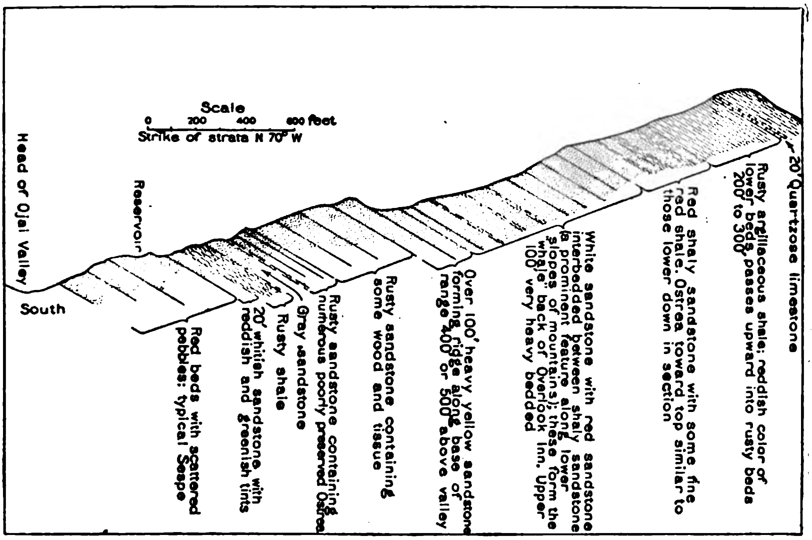
Scale
0 200 400 600 feet
Strike of strata N 70° W
Head of Ojai Valley
Reservoir
South
Red beds with scattered pebbles: typical Sespe
20' whitish sandstone with reddish and greenish tints
Rusty shale
Gray sandstone
Rusty sandstone containing numerous poorly preserved Ostrea
Rusty sandstone containing some wood and tissue
Over 100' heavy yellow sandstone forming ridge along base of range 400' or 500' above valley
White sandstone with red sandstone interbedded between shaly sandstone (a prominent feature along lower slopes of mountains); these form the "whale" back of Overlook Inn. Upper 100' very heavy bedded
Red shaly sandstone with some fine red shale. Ostrea toward top similar to those lower down in section
Rusty argillaceous shale; reddish color of lower beds passes upward into rusty beds 200' to 300'
20' Quartzose limestone

FIG. 3.—North-south section on north side of Lower Ojai Valley, showing lithologic variation in strata.

RED BEDS IN THE OJAI VALLEY.

The Sespe formation or what is believed to be its stratigraphic equivalent in the Ojai Valley consists of conglomerates, sandstones, and shales, bright red and white, the former color largely predominating. The red beds are not so unbroken, however, as in Sespe Canyon. On the contrary they are interrupted not only by certain white sandstones, but also by very considerable bodies of rusty sediments, which in some instances suggest a transition to the formation that is possibly the equivalent of the Topatopa. This lithologic variation is illustrated in the accompanying profile (fig. 3), which is taken from the lower slopes of the range bordering the Lower Ojai Valley on the north. The shales of the formation are not conspicuous, except in the region of Lion Canyon, where a thickness of between 50 and 100 feet in a single body is attained, the colors being rusty, gray, red, blue, and black.

RED BEDS SOUTH OF THE SANTA CLARA.

Certain evidence, which is as yet inconclusive, leads to the belief that south of Santa Clara River the Sespe formation is represented by a succession of gray and red-banded sandstones and coarse arenaceous clays that are conspicuous along the lower slopes of Oak Ridge. The rocks correspond in composition to those of Sespe Canyon. The red color is similar in both localities, and the overlying formation in both instances bears lower Miocene fossils. In the heart of the anticline which passes along the front of Oak Ridge a short distance above its base the Sespe consists of a massive rusty-yellow sandstone, bearing layers of small granitic pebbles. The sandstone in fresh fractures is locally brown, apparently from having once been impregnated with petroleum. Immediately overlying it are from 150 to 400 feet of banded bright-red and gray sandstones, argillaceous sands, and arenaceous clays. The transition is in some instances gradual, in others sharp and pronounced. The red and gray beds are also repeated beneath the rusty-yellow sandstone first described, as is evidenced in the wells of the Bardsdale Crude Oil Company, sunk adjacent to the axis of the anticline, a mile west of Grimes Canyon. Both red and gray beds are locally conglomeratic, the pebbles comprising clear quartz, red and blue quartzites, granite, chert, eruptives, and metamorphic rocks of several varieties. Small bodies of white limestone also occur here and there, interbedded in the formation.

OIL IN THE RED BEDS.

North of the Santa Clara oil has been produced in considerable quantity at a number of horizons in the red beds, and south of the river, in at least one locality, the suggested homologues have also yielded some oil.

UPPER ZONE.

Immediately overlying the body of red beds is about 500 feet of ferruginous, greenish-gray calcareous sandstone, in layers 8 to 10 feet thick, separated by thin bands of shale. Certain beds of the sandstone are so calcareous as to be almost sandy limestones. These are fossiliferous in many places, although no well-preserved forms were obtained. Oysters appear to predominate. The zone of sandstone thus defined is best seen in the ridge dividing Little Sespe Creek and its tributary, Fourfork Creek, from Tar Creek, and in the valley of the latter, where it appears as a conspicuous parting between the red beds below and the great series of Vaqueros shales above.

RELATION OF UPPER SESPE BEDS TO VAQUEROS SHALE.

No sharp lines of distinction separate the upper Sespe terrane from the underlying red beds or the overlying Vaqueros. On the contrary, there is a perceptible tendency for the terranes to shade one into another. Fossils of value have not yet been collected from this transitional zone. There is, therefore, some uncertainty as to whether the beds in question should be referred to the Eocene or the Miocene. The red beds proper are commonly regarded as of Eocene age. In Sespe Canyon fragments of grayish-yellow sandstone, coming either from some horizon unrecognized but well up in the red beds or from a horizon corresponding to that of the rusty beds just described, have been found bearing well-marked Eocene fossils, among which are the forms *Venericardia planicosta* Lamarck (Pl. XXV, fig. 1) and *Turritella uvasana* Conrad (Pl. XLI, figs. 2 and 3). Beds of a similar nature, with an abundance of Tejon (Eocene) fossils, also occur along the northern edge of the Silver Thread oil field, west of Santa Paula Canyon, overlying certain pink and gray sandstones that are believed, on lithologic grounds, to belong to the Sespe. The following species have been found at this locality. With one exception they were identified by the late J. G. Cooper.[a]

Sespe (Eocene) fossils from north side of Sisar Creek, west of Santa Paula Creek.

Anatina sp.
Cardium linteum Conrad.
Corbula n. sp.
Dentalium cooperi Gabb.
Leda gabbi Conrad.
Leda n. sp.
Meretrix californiana Conrad.
Nassa cretacea Gabb.
Neæra dolabriformis Gabb.
Nucula truncata Gabb.
Nucula solitaria Gabb.
Pecten calkinsi Arnold.
Pecten interradiatus Gabb.
Solen parallelus Gabb.
Spirocrypta pileum Gabb.
Tellina hoffmaniana Gabb.
Tellina longa Gabb.
Tellina parilis Gabb.
Thracia semiplanata Whiteaves.
Turbonilla n. sp.
Yoldia arata Whiteaves.
Yoldia nasuta Gabb.

It may be, therefore, that the rocks in question represent the uppermost member of the Eocene in the region of the Santa Clara and the mountains to the north. On the other hand, the resemblance of several of the beds of this transitional zone to others a little higher in horizon, that bear identified Oligocene or lower Miocene forms, is to be borne in mind. To determine satisfactorily the limits not only of this, but of all the other formations in the Santa Clara district, a large amount of field work will be required. The difficulty will be enhanced, too, by the highly disturbed condition of the rocks and the complicated structural relations which they bear one to another, unless distinctly characteristic fossils are found to correlate the beds of the several localities. Tentatively, however, the line between the Sespe (Eocene) and the Vaqueros (lower Miocene) formations has been drawn at an indefinite horizon in the rusty beds described, at a point where the sandstone no longer predominates but is largely replaced by shale, yet below the lowermost lower Miocene fossils found.

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[a] Bull. California State Mining Bureau No. 11, 1897, pp. 84-85.

OIL IN THE UPPER SESPE BEDS.

It is probable that a portion of the oil yielded by the Fourfork and Tar Creek wells has been drawn from the rusty series at the summit of the red beds or else from similar thinner beds in the lower part of the Vaqueros formation. It will be observed that the entire series of beds designated the Sespe shows a remarkable distribution of petroleum, in both its vertical and horizontal extent.

VAQUEROS FORMATION.

AGE AND GENERAL CHARACTER.

The formation designated Vaqueros, appears to be largely lower Miocene. The position of 3,000 feet of shale, such as make up the Vaqueros, below beds which are certainly well down in the Miocene, suggests the possibility that the lower part of the shale extends into the Oligocene. By a rough estimate the maximum thickness of the Vaqueros formation is between 2,000 and 3,000 feet, but the amount of sediment deposited evidently varied greatly from point to point. From the base upward the following more or less distinct zones are recognizable: Shales, purplish, rusty, and gray in color, purplish prevailing, perhaps 500 feet; a conspicuous zone of gray shale, 500 feet; a series of deep maroon, brown, and gray shales, approximately 700 feet; and an upper body of siliceous shale and limestone, gray, but weathering a pronounced yellow, 500 or 600 feet. The formation is therefore distinctly one of shale from top to bottom. Throughout its extent lenticular limestones occur, with a tendency to form continuous bands a foot or two thick. Much of the shale also is calcareous.

Through the lower half of the basal purplish zone are threaded thin layers of calcareous grits or gritty limestones. Where the quartz ingredient is sufficient, they resemble certain beds in the underlying rusty zone at the top of the Sespe formation. These beds are fossiliferous, and from them were gathered the following representative forms, determined by Ralph Arnold:

Fossils from Vaqueros formation.

TAR CREEK, BY TRAIL SIDE.

Modiolus sp.
Ostrea cf. idriaensis Gabb.
Pecten sespeensis Arnold (Pl. XXXIII, figs. 1, 1a, 2).
Turritella ineziana Conrad var. sespeensis Arnold (Pl. XLI, fig. 6).

IN TRIBUTARY ENTERING LITTLE SESPE CREEK AT FOOT-OF-THE-HILL WELLS.

Balanus concavus Bronn. (Pl. XXXII, figs. 5, 5a).
Pecten sespeensis var. hydei Arnold (Pl. XXXI, fig. 2).
Placunanomia sp.
Scutella fairbanksi Merriam (Pl. XXIX, fig. 3; Pl. XXX, fig. 3).

LITTLE SESPE CREEK, BELOW FOOT-OF-THE-HILL WELLS.

Balanus concavus Bronn. (Pl. XXXII, figs. 5, 5a).
Pecten sespeensis Arnold (type locality) (Pl. XXXIII, figs. 1, 1a, 2).
Trophon n. sp. (large).
Turritella ineziana Conrad var. sespeensis Arnold (Pl. XLI, fig. 6).

The limestones bearing these fossils are conspicuous in their persistency. One or another appears at intervals for several miles along the Tar Creek trail; again on upper Fourfork Creek, half a mile west of the upper wells; on Little Sespe Creek below the Foot-of-the-Hill wells; and in a tributary that enters Little Sespe Creek in the vicinity of the Foot-of-the-Hill wells. Besides the foregoing fossils, both shale and limestone, from base to summit of the formation, afford an abundance of foraminifera and fish integuments. The Vaqueros thus exhibits a degree of lithologic and paleontologic resemblance to the shale of the overlying Modelo formation. The stratigraphic position and unique fauna, however, determine the age of these beds, and the sharp line between them and the Modelo sandstones above indicates that the division between the two formations should be located at that plane.

About 30 feet below the contact of the gray and overlying maroon shale is a very persistent band of gray sandstone from 10 to 40 feet thick, the outcrop of which may be readily seen about the extensive amphitheater drained by Tar Creek.

The upper series, of calcareous and siliceous shales, is strikingly similar in appearance to the Modelo of adjacent localities; moreover, they abound in foraminiferal forms. Were the Modelo sandstone to disappear and the shales of the Vaqueros and upper Modelo to be brought in contact it would be impossible to distinguish a break of importance in the entire succession. It is suspected, indeed, that this has happened in the western face of Oat Mountain and in the ridge running southward, although with a thinning of the series as a whole.

VAQUEROS BEDS IN THE OJAI VALLEY.

The Vaqueros formation in the Ojai Valley is composed of rust-colored conglomerate, sandstone, and shale, together with interlaminated limestone. The conglomerates carry pebbles up to 2 inches in diameter of black chert, white quartzite, gray granite, and purple, green, and maroon eruptives. In places, also, there are pebbles that possibly may have been derived from some outcrop of the Franciscan formation not far distant. The matrix of the conglomerate is composed of the same materials as the pebbles.

The sandstone bears a striking resemblance to that in the lower portion of the Vaqueros formation in the vicinity of Tar Creek, without, however, the strong development that it has there.

The shale is argillaceous, fissile, and primarily of a blue-gray color, but this is modified to such an extent by the presence of iron that weathered surfaces and hill slopes are prevailingly rusty. Here and there faint tinges of red, pink, purple, and green are to be observed, shades that characterize the formation in the Tar Creek and Fourfork region.

The limestone beds of the formation vary from a few inches to 6 feet in thickness. They carry a large proportion of quartzose material and commonly show the presence of comminuted to more or less perfect oysters. Locally, also, they are found rich in other remains, notably pectens, turritellas, and barnacles, all of enormous size.

The following list of fossils, collected by the writer and identified by Ralph Arnold, indicates the general character of the fauna in these beds:

Fossils from the Vaqueros formation of the Ojai Valley.

SOUTH FORK AT HEAD OF LOWER VALLEY, ONE-FOURTH OF A MILE ABOVE OLD REFINERY.

Chione temblorensis Anderson (Pl. XXX, fig. 1).
Mytilus mathewsonii Gabb var. expansus Arnold (Pl. XXX, fig. 2).
Neverita sp. indet.
Pecten magnolia Conrad (Pl. XXVIII, fig. 1).
Pecten vaughani Arnold (Pl. XXXIII, figs. 3, 3*a*).
Tritonium, three sp.
Trophon n. sp. (large).
Turritella ineziana Conrad (Pl. XLI, fig. 5).

EAST END OF CREST OF RIDGE BETWEEN UPPER AND LOWER VALLEYS.

Balanus sp.
Chione sp.
Dentalium sp.
Leda sp.
Nassa sp.
Ostrea sp.
Pecten crassicardo Conrad (Pl. XXXI, fig. 1).
Pecten lompocensis Arnold (Pl. XXIX, fig. 1).
Phacoides sp. (flat).
Tritonium or Fusus sp.
Turritella cf. ineziana Conrad (young).

The precise area of outcrop of the supposed Vaqueros beds in the Ojai Valley has not been defined, but one of the principal exposures, which afforded the fossils above enumerated, occurs along Refinery Gulch on the south side of the upper portion of the Lower Ojai Valley. A second exposure is that in the locality of the section illustrated in fig. 3. The lithologic features of this section indicate the correlation of the red and white sandstones with the Sespe red beds and of the overlying fossiliferous rusty beds with the Vaqueros formation, the heavy body of rusty sandstones occurring at the base of the Vaqueros in the Tar Creek locality being possibly a variable factor from one point to another.

VAQUEROS FORMATION SOUTH OF THE SANTA CLARA.

South of the Santa Clara, along South Mountain, Oak Ridge, and the Santa Susana Mountains, is a body of shale, sandstone, conglomerate, and limestone, identified by their fossils with the Vaqueros, but at variance with that formation north of the Santa Clara in the accession of conglomerate and in the relative proportions of the other sediments. Sandstone, for instance, is far more abundant in the formation south of the Santa Clara than north of it. Moreover, the thickness of the beds is greatly reduced south of the river, a minimum of 400 or 500 feet appearing in Oak Ridge and South Mountain, increasing to about 1,000 feet in the Santa Susana Mountains.

The formation south of the Santa Clara, in its simplest form, consists of 300 or 400 feet of banded chocolate and gray argillaceous and arenaceous shales, sandstones, scattered limestone concretions, and more or less persistent mollusca-bearing calcareous grits, similar to the fossiliferous Vaqueros formation of the Tar Creek amphitheater. As a rule 50 to 100 feet of massive, coarse gray to yellow sandstone, also yielding lower Miocene remains, separate the formation from the red and gray banded beds below, and another very similar bed, 40 or 50 feet thick, carrying fossils of the same age, marks the summit of the terrane. This upper sandstone divides the underlying shale from 200 or 300 feet of other shale that is more siliceous and chalky and nearer the Monterey type.

Locally the shale of the Vaqueros formation south of the Santa Clara, in addition to its chocolate and gray colors, assumes faint green, blue, and red hues. Thin layers of white limestone appear here and there, some of which is highly crystalline, with almost the aspect of marble. The sandstone, particularly in the eastern half of the field, where it is better developed, carries spherical concretions resembling those of the lower Modelo stratum north of the Santa Clara. Besides the molluscan remains, casts and imprints of foraminifera are common in the calcareous and siliceous members from base to summit of the formation. Toward its top a yellow color is to be observed at many places, pervading alike both shale and sandstone.

The foregoing description of the Vaqueros south of Santa Clara River is more particularly applicable to that portion of the formation which lies west of Garberson Canyon. East of this region considerable modification occurs. In Wiley Canyon, for instance, the heavy sandstone that forms so conspicuous a feature immediately above the red and gray banded beds at the foot of the main range is doubtless the local representative not only of the sandstone bed farther west, but also of a considerable proportion of the chocolate and gray banded sands and clays that overlie that bed. The change in the composition of the beds is gradual and can be readily followed. The correlation of the sandstone is finally established by the presence of fossils. It carries pebbles of granitic and other débris up to 4 inches in diameter and concretions which, as already mentioned, closely resemble those of the lower Modelo sandstone north of the Santa Clara. The full thickness of the bed at Wiley Canyon can hardly be less than 600 feet and is perhaps even in excess of this. It is overlain by 100 or 200 feet of gray and brown arenaceous shales and sands, a remnant of the beds that are so characteristic of the formation farther west, and these are succeeded by approximately 200 feet of thin-bedded yellow sand and 100 feet of brown, gray, and white shale, which constitutes the uppermost member of the formation. The total thickness between the red and gray banded sandstone and shale of possible Eocene age and the siliceous shale of Monterey type capping the crest of the mountain is probably not less than 1,000 feet.

The beds cut by Tapo Canyon are broadly separable into the same formations as elsewhere in the Santa Susana Mountains, but their defining lines are more or less indistinct, and in some places it is not certain to which of the two principal formations the strata should be referred. There appears to be conformability, not to suggest transition, between the Miocene and Pliocene series at this point, although unconformability is the rule over the Coast Range territory. The younger series is, however, marked by conglomerates, while the older is more shaly and its sandstones are more thinly bedded. Here and there the older sandstones are concretionary. The shales are brown or chocolate colored, show a siliceous tendency, and increase in proportion to the sandstones as depth in the series is gained. In the ridge between the middle and east forks of Tapo Creek fully 400 or 500 feet of shale, with a minimum of sandstone, underlies the higher, more sandy members. Both shale and sandstone are locally bituminous, and from them come several oil seepages of importance. In this series the wells of Tapo Canyon have been sunk. The foregoing description of the older succession of strata in these canyons suggests correlation with the banded sands and chocolate-colored shale of Torrey and Wiley canyons and even in part with the Modelo north of the Santa Clara, though no fossils have been observed in either group of beds. In Tapo Canyon there is not less than 2,000 feet of the formation exposed, in Wiley Canyon the thickness is less than 1,000 feet, and farther west it is barely 500 feet.

In the region of Pico Canyon and to the southeast the beds mapped as Vaqueros consist of a great mass of thin-bedded shale overlain by brown shale, with some more or less important sandstone layers. Above these occur conglomerate, sandstone, and arenaceous clay, which are believed to belong to the Fernando formation, and are so mapped, although no sharp line of demarcation was discovered between the two formations.

The following fossils have been obtained from beds mapped as Vaqueros in the region south of Santa Clara River. Owing to the limited number of species represented the correlations are necessarily very broad. The identifications are by Ralph Arnold.

Fossils from Vaqueros formation south of Santa Clara River.

ELKIN'S RANCH, OAK RIDGE, EAST OF GRIMES CANYON.

Ostrea eldridgei Arnold (Pl. XXIX, figs. 2, 2a).
Turritella ineziana Conrad var. (Pl. XLI, fig. 4).

GULCH EAST OF WILEY CANYON.

Pecten (Hinnites) giganteus Gray (Pl. XXXII, fig. 1).
Turritella ineziana Conrad var. (Pl. XLI, fig. 4).

CHAFFEE CANYON.

Cardium n. sp.
Dosinia n. sp.
Ostrea sp. aff. titan Conrad.
Panopea generosa Gould var.
Phacoides sp.
Acmæa or Trochita sp.
Turritella cf. ineziana Conrad.

TORREY CANYON AND VICINITY.

Scutella fairbanksi Merriam (Pl. XXIX, fig. 3, and Pl. XXX, fig. 3).
Mytilus mathewsonii Gabb var. expansus Arnold (Pl. XXX, fig. 2).
Ostrea sp. aff. titan Conrad.
Pecten sespeensis var. hydei Arnold (Pl. XXXI, fig. 2).

MODELO FORMATION.

GENERAL CHARACTER.

The Modelo formation embraces at least two prominent bodies of sandstone and two of shale. The shale at many points bears a marked resemblance to that of the Monterey (middle Miocene), both from a lithologic and a paleontologic standpoint, and it may be that it is the correlative of that formation. The Modelo is distributed over a broad area north of the Santa Clara Valley and through folding and faulting its members are brought into most complex relationships. However, it is believed that the distinctions given below will serve as a satisfactory means of differentiation.

LOWER SANDSTONE.

The lowest member, a massive, heavy-bedded sandstone, rests directly and apparently conformably upon the Vaqueros shale. It varies in thickness from 200 or 300 feet to perhaps 1,500 or 2,000 feet. It is white to yellowish gray in color. Locally the sandstone is gritty, bearing also a dark-gray to black chert, and a few pebbles of another sandstone. It contains spherical and elliptical concretions from 1 foot to 5 feet in diameter, which are so prominent and so resistant to weathering as to form a conspicuous characteristic of the member, the more so because ot the utter lack of such concretionary bodies in a second, otherwise similar sandstone that occurs higher up. The upper half of the sandstone is less concretionary than the lower and is also thinner bedded, the layers being separated by shale of a dark-drab color, which carry scattered gray limestone concretions that weather yellow. Traces of organic life are also visible. This member is usually stained dark with petroleum.

This lower sandstone early received the name Modelo, but the writer has thought it best to assign the name tentatively to the entire formation described in the opening lines of this section. The sandstone is best displayed in the bold escarpment east of Tar Creek and is also heavily developed in Hopper Canyon and at the head of Modelo Canyon. A large number of productive wells have been drilled in Modelo Canyon, the oil being doubtless derived from some of the lower horizons of the formation. Plate II, *A*, gives an idea of the appearance of this sandstone in the region north of the Modelo wells.

UPPER SANDSTONE.

The upper sandstone of the Modelo formation is but little less conspicuous than the lower, although its maximum thickness has been estimated at only 900 feet and in many places it is even less. It has the same mineral constitution as the lower bed, being composed of white, subangular quartz, with a trace of the salts of iron, which have colored it slightly yellowish. A considerable amount of dark chert is also present, and in one locality beautiful green and brown pebbles of siliceous shale were observed. The member is, however, nonconcretionary. It is also thinner bedded than the lower sandstone and for 100 feet at the base is not only comparatively micaceous, but is split by minor bodies of shale, the whole somewhat darker than the portion overlying, seemingly from the presence of dried petroleum. This portion weathers a peculiar bluish gray.

This sandstone is conspicuously developed in the region of Hopper Canyon, where it lies in a well-marked syncline that to the east is sharply compressed and, perhaps, faulted. South of this syncline the sandstone is involved in one or two other folds and finally, between Hopper and Nigger canyons, passes beneath the Santa Clara Valley.

SHALE IN THE MODELO.

The two sandstones described above are divided by a body of earthy shale, gray to brown, which bears limestone concretions weathering yellow and whose thickness has been variously estimated at 400 to 1,600 feet. Overlying the upper sandstone is a second body of shale, of uncertain thickness owing to the fact that in the region under discussion not only has erosion removed the sediments down to an undetermined horizon in the formation, but an unconformity also exists between this and the overlying formation. However, the thickness is variously estimated at between 200 and 1,500 feet, according to locality. This shale is indistinguishable from that separating the two Modelo sandstones already described. Both vary from a granular, siliceous type to one of an earthy and fissile character, more readily breaking down under the influence of weathering. The color of the lower bed is commonly light gray; that of the upper may be brown, gray, or yellowish. Both bodies carry calcareous layers and here and there lenticular limestone concretions that weather yellow. Were the upper sandstone to disappear the shales above and below would become a single mass, uniform in their general features, from top to bottom; were both sandstones to disappear it would be difficult to distinguish these rocks from the upper portion of the Vaqueros formation. They would be more readily differentiated from the lower portion of the Vaqueros, however, by the variety of color in the older beds and by the marked change to the rusty, calcereo-arenaceous grit at their base.

VARIATION IN COMPOSITION OF THE MODELO.

The foregoing paragraphs describe what appears to be the normal section of the Modelo formation, but the aspect varies somewhat from point to point, by reason of the subdivision of the sandstones and the changes in their relative porportion to the formation as a whole. At the head of Modelo Canyon, for instance, the outcropping portion of the lower sandstone appears to be split into two bodies, each 300 feet thick, by 60 to 100 feet of shale, and a similar division is shown by the logs of wells drilled in this canyon. What may prove to be the upper sandstone is separated from the lower by only about 200 feet of brown shale as compared with 400 to 1,600 feet in the normal section. The enormous development of the Modelo sandstones in the lofty divide separating Tar Creek from the drainage of Hopper Canyon and Piru Creek is also at variance with the average thickness of either of these members, and it may be that the shales are reduced to a minimum in this locality, resulting in a sandstone facies for this formation amounting to at least 2,000 feet.

South of Santa Clara River the Modelo formation is unrecognized, nor is it possible to find for it a proved correlative. Certain sandstones assigned here to the Vaqueros terrane carry concretions that closely resemble those in the lower Modelo sandstone, and the associated shale is also very much like the shales of the Modelo series north of the river. Yet these beds south of the Santa Clara contain fossils similar in a measure to those of the lower members of the Vaqueros in the Tar Creek, Little Sespe, and adjacent districts. This, with the diminished thickness south of the river, suggests a rapid and marked variation in conditions during the sedimentation of these mportant formations in the Santa Clara Valley.

All the shales of the Modelo formation, as well as those of the Vaqueros, carry at one horizon or another minute foraminiferal remains and fish integuments, similar in general appearance to those commonly present in the Monterey shale in other portions of California.

Many of the layers in the Miocene shales, whether older or younger, are flecked with particles of dried bitumen, indicating a general distribution of petroleum throughout the shales and suggesting that it may have been derived from the abundant organic life once present in them.

The lower Modelo sandstone also bears considerable bitumen in the region of Modelo Canyon, and it is said that in summer it yields numerous seepages of a comparatively light petroleum.

SUPPOSED MODELO BEDS IN THE OJAI VALLEY AND SULPHUR MOUNTAIN.

The supposed equivalent of the Modelo in the Ojai Valley and Sulphur Mountain is confined to beds similar to those which characterize the upper portion of the formation in the type locality; that is, it consists of shale, siliceous, chalky, or earthy, in color white, gray, or locally maroon, carrying the customary limestone concretions and interbedded here and there with sandstone of fine grain and a thickness up to 10 or 15 feet. In the shale are found the usual foraminiferal remains, abundant pieces of fish integument, and, it is reported, even bony fish skeletons. The soil formed by the disintegration of the formation is black. The extreme silicification that is so common a feature of the shale immediately at and below a mountain crest in other localities is repeated in Sulphur Mountain. The thickness of the formation in the region under discussion seems to be at least 1,500 feet.

CORRELATION OF THE UPPER SHALY PORTION OF THE MODELO WITH THE MONTEREY SHALE.

In the Santa Clara district the presence of the Monterey formation is uncertain, although the uppermost shale of the Modelo north of the river and the great mass of siliceous shale and "chalk rock" that so conspicuously caps the Santa Susana Mountains, Oak Ridge, and South Mountain, south of the river, may be a part of it. Only one fossil, the cast of a thin flat pecten, closely resembling *Pecten pedroanus* Trask (Pl. XXXVI, figs. 5, 6), has so far been found in these shales; this was obtained in the outcrop immediately east of the road in Sulphur Canyon, southwest of Bardsdale. This evidence, however, supports the suspected correlation, which otherwise is based on lithologic resemblances only. It might be well to say, furthermore, that the type locality of *Pecten peckhami* Gabb (Pl. XXXI, fig. 3) is the Ojai Valley (probably in the shale on the south side) and that this species is unusually abundant in the Monterey shale in most regions where the formation is known.

DIFFICULTIES OF CORRELATION BETWEEN NORTH AND SOUTH SIDES OF SANTA CLARA VALLEY.

The division of the great series of beds north of the Santa Clara into the Vaqueros and Modelo is made easy by the abrupt and marked change in the character of the sediments at the contact of the lower Modelo sandstone and the underlying shale. South of the river this division does not appear to hold, yet one or another of the characteristics of the Miocene, taken as a whole, north of the river reappears on the south side, suggesting that the beds on both sides of the valley from base to summit should be included in a single formation. The difficulty of correlation south of the river is greatly increased by the presence of sharp folds and faults. For example, in the normal succession the siliceous shale and the "chalk rock" unquestionably overlie beds of altogether different character, identified as the Vaqueros; yet at the east end of Oak Ridge and in the western portion of the Santa Susana Mountains an equally heavy body of siliceous shale appears to dip beneath similar shale that is believed to be of lower Miocene age. This unusual succession may be attributable to faulting, the siliceous shale being the younger. On the other hand, it may possibly be that the siliceous shale capping Oak Ridge corresponds to the mass of siliceous shale that occurs as the uppermost of the Vaqueros beds in their type locality. In this case the Modelo would be entirely wanting south of the river.

Another element in the difficulty of correlating the formations on opposite sides of Santa Clara River is the remarkable decrease in thickness toward the south. It would seem that the formations referred to have their type and maximum development north of the Santa Clara, and that south of the river the formations are thin, either through lack of material or through rapid changes in the attitude of the land, which resulted in intervals of nondeposition or even of erosion during the time the beds were being laid down.

BURNING OF THE SHALE.

The siliceous shale and "chalk rock" forming the crest of the mountains south of the Santa Clara have at many points been burned to a bright-red color. The fuel which supported such fires was perhaps the originally contained petroleum.

Opposed to this view, however, is the very considerable depth to which the shale has been altered to a brilliant-red lava-like rock; hence it may be inferred that spontaneous combustion alone has brought about the modification.

FERNANDO FORMATION.

GENERAL CHARACTER AND AGE.

The rocks that have received the name Fernando[a] consist of an enormous succession of conglomerates, sandstones, and arenaceous clays, largely of Pliocene age, developed over considerable portions of southern California. Fossils collected at many localities and at many horizons throughout the formation indicate that it extends from the upper Miocene (San Pablo formation of the general geologic column of the State) well up in the Pleistocene (San Pedro formation). It is possible to subdivide the formation locally on both lithologic and paleontologic grounds, but taken over a considerable extent of territory these divisions merge into one another both stratigraphically and geographically by insensible gradations. An unconformity usually marks both the base and the top of the formation, although in several localities in the Santa Clara region that at the base is difficult if not impossible to detect.

Along the sides of the Santa Susana Mountains and Oak Ridge and in the region east of Newhall the coarser beds of this formation are usually white, gray, or yellow, the clays bluish gray. The material of the conglomerate is principally granitic, but pebbles of the intermediate formations are occasionally found. In the limited region under survey no established succession of the different sediments was observed, although a broader field would doubtless reveal it. The unconformities are always to be reckoned with, and to them may be due in large measure the variations in the rocks that are in contact. Incidentally it may be observed that perhaps to them also may be due the fact that whereas south of the general fold out of which the several ranges are formed the Fernando is usually in contact with siliceous shale, north of the anticline, on the slopes of the Santa Susana Mountains, it is found resting directly upon beds that are of the Vaqueros facies.

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[a] A term applied in unpublished maps by Homer Hamlin a number of years ago to the beds above the siliceous shale skirting the sides of the San Fernando Valley, Los Angeles County—the general equivalents of all the post-Modelo, pre-Saugus beds in the Santa Clara province.

In the vicinity of the Piru Valley the Fernando formation consists in ascending order of (1) a thick body of sandstone and conglomerate; (2) sandy shale and clay; and (3) heavy-bedded coarse conglomerate. These form the northern slope of the ridge north of Camulos, the distance of about 4,000 feet being equally divided among them. Overlying the upper conglomerate are several hundred feet of greenish-gray clay, and it is believed that this is succeeded in turn by 1,500 to 2,000 feet of alternating sandstone and conglomerate. If the succession is continued, clays then follow to the valley of the Santa Clara. In all, the formation is fully 5,000 or 6,000 feet thick in this vicinity, and if its thickness could be determined over the entire area that amount would doubtless be increased by many thousands of feet. The materials of the conglomerates include granite, shale derived from the Miocene, and a few eruptives.

North of the Santa Clara Valley, extending from the mouth of Sespe Canyon westward to the Pacific Ocean at Ventura, is another extensive area of the Fernando. The formation is best developed in the hills between Santa Clara River and Sulphur Mountain, where the succession consists of sandstones and conglomerates, underlain by a thick body of clay dirt-brown to gray in color. This clay is arenaceous and grades into sandstone both transverse to the strata and along the strike. In places even pebbly layers may be found in this part of the formation. Beneath the clay is another mass of heavy-bedded sandstone and conglomerate, separated by minor layers of clay, resembling that just described. If there are not faults in these beds—and none were detected—the thickness can hardly be less than 8,000 or 10,000 feet, about equally divided between the three varieties of sediments mentioned. Some of the lower sands are bituminous and their associated clays are brown or blue.

On the lower slopes of San Cayetano Mountain, making up a part of the area outlined in the preceding paragraph, is a mass of gray clay and shale, sandstone, and heavy gravel beds, all more or less hardened and resistant to weathering, which belong to the upper Fernando. The pebbles making up the gravel deposits are granite, quartsite, sandstone, limestone, and the harder shale all derived from the mountains of the Sespe region.

PALEONTOLOGY OF THE FERNANDO FORMATION.

At least three distinct faunas are recognizable in the Fernando, representing what are thought to be in a very general way the bottom, middle, and top of the formation. The oldest fauna was found in the area north and northeast of Camulos, and is, according to J. C. Merriam, the equivalent of the fauna of at least a part of the San Pablo formation. The middle fauna was found well developed in the region of Elsmere Canyon and Fernando Pass, and probably represents the typical fossiliferous portion of the Purisima and the lower part of the San Diego formation. The upper portion of the Fernando extends well up into the Pleistocene, as is attested by the fossils found at Barlow's ranch and on the south slopes of Mount San Cayetano; these have been correlated with the fauna contained in the San Pedro formation.

LOWER FERNANDO FAUNA.

The following species have been found in what is supposed to be the oldest portion of the Fernando, in the region north of Camulos:[a]

Fossils from the lower part of the Fernando formation, near Camulos.

[Those marked "a" are from the light-colored shale underlying the conglomerate on Santa Felicia Creek; "b," from conglomerate 5 miles northeast of Camulos; "c," from fine conglomerate and coarse sandstone 1 mile north of Camulos; "d," from coarse conglomerate 1 mile north of Camulos; "e," from conglomerate on the east side of Piru Creek, near the railroad bridge.]

Arca camuloensis Osmont (b, d) (Pl. XXXVII, figs. 1, 1a, 1b).
Bulloid n. sp. (c).
Callista subdiaphana Carpenter (c) (Pl. XXXIX, fig. 3).
Cancellaria n. sp. (b).
Cardium sp. (b).
Chlorostoma sp. (c).
Chrysodomus n. sp. (1) (b).
Chrysodomus n. sp. (2) (c, d).
Conus californicus Hinds (b, e).
Conus cast, sp. indet. (c).
Corbula n. sp. (c).
Dosinia ponderosa Gray? (c).
Echinarachnius, near excentricus Eschscholtz (a).
Fusus rugosus Trask (d).
Leda taphria Dall (b, c) (Pl. XXXVIII, fig. 5).
Lunatia lewisii Gould (c, d).
Macoma, near secta Conrad (a).
Macoma secta Conrad (b).
Mangilia sp., probably new (c).
Metis alta Conrad? (d).
Nassa californiana Conrad (b).
Nucula castrensis Hinds (d).
Nucula n. sp. (c, d).
Ostrea veatchii Gabb (d) (Pl. XXXIX, fig. 1).
Pachypoma n. sp. (a, b).
Pecten bellus Conrad (e) (Pl. XXXV, fig. 3).
Pecten cerrosensis Gabb (c, d) (Pl. XXXV, fig. 6).
Pecten merriami Arnold (a) (Pl. XXXVI, fig. 9).
Priene oregonensis Redfield var. angelensis Arnold (Pl. XL, fig. 11)
Phacoides sp., probably new (b).
Solen sicarius Gould (a).
Turritella n. sp. (b).
Yoldia scissurata Dall (c).

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[a] Collected by W. L. Watts; identified by J. C. Merriam; listed in Bull. California State Mining Bureau No. 19, 1900, pp. 220-222.

MIDDLE FERNANDO FAUNA.

The following species, found in Elsmere Canyon and the region of Fernando Pass, apparently represent a somewhat later fauna than that just described. The identifications are by Ralph Arnold.

Fossils from the middle of the Fernando formation, Elsmere Canyon.

Amiantis callosa Conrad (Pl. XXXIX, fig. 2).
Arca trilineata Conrad (Pl. XXXVIII, figs. 3, 4).
Callista subdiaphana Carpenter (Pl. XXXIX, fig. 3).
Cancellaria fernandoensis Arnold (Pl. XL, fig. 4).
Cardium quadrigenarium Conrad var. fernandoensis Arnold (Pl. XXXVIII, fig. 2).
Chione n. sp. (small).
Chrysodomus arnoldi Rivers.
Cryptomya californica Conrad.
Cypræa fernandoensis Arnold (Pl. XL, fig. 8).
Dolichotoma cf. carpenteriana Gabb.
Macoma indentata Carpenter.
Macoma sp.
Mactra cf. hemphilli Dall.
Modiolus rectus Conrad.
Monia macroschisma Dall.
Murex eldridgei Arnold (Pl. XL, fig. 12).
Mya truncata Linné.
Neptunea humerosa Gabb.
Neverita recluziana Petit (Pl. XXXVIII, fig. 6).
Olivella intorta Carpenter.
Panopea generosa Gould.
Pecten cf. caurinus Gould (Pl. XXXVI, fig. 1).
Pecten estrellanus Conrad var. catalinæ Arnold.
Pecten healeyi Arnold, 17 rib. var. (Pl. XXXIV, fig. 1).
Pecten cf. parmeleei Dall (Pl. XXXVI, fig. 7).
Phacoides acutilineatus Conrad.
Pisania fortis Carpenter var. angulata Arnold (Pl. XL, figs. 6 and 7).
Priene oregonensis Redfield, var. angelensis Arnold (Pl. XL, fig. 11).
Tapes tenerrima Carpenter.
Tellina idæ Dall (?).
Tritonium sp.
Trochita filosa Gabb (Pl. XL, figs. 2, 2a).
Turritella cooperi Carpenter, var. fernandoensis Arnold (Pl. XLI, fig. 13).

UPPER FERNANDO FAUNA.

Lists of species from three localities are given to show the characteristics of the fauna of the upper portion of the Fernando. The fossils in the first list may possibly be slightly older than those in the second, which in turn appear to be a little older than those in the third. The species from Barlow's ranch have been correlated with the fauna contained in the upper fossiliferous beds at San Pedro, which are well up in the Pleistocene.

Fossils from the upper part of the Fernando formation.

NORTHWEST OF SANTA PAULA.[a]

[Those followed by an "E" are from Goat Mountain, near the mouth of Adams Canyon; those followed by an "F" are from Santa Paula Creek, between Mupa schoolhouse and Sulphur Mountain.]

Astrodapsis whitneyi Conrad (F).
Astyris richthofeni Gabb (E).
Bittium aspersum Gabb (E).
Cardium corbis Conrad (E).
Cardium procerum Sowerby (F).
Chione mathewsoni Gabb (F).
Chione whitneyi Gabb (F).
Chorus belcheri Hinds (F).
Clidiophora punctata Conrad (E).
Crepidula princeps Conrad (E).
Cryptomya californica Conrad (E).
Dentalium semipolitum Broderip (F).
Echinarachnius excentricus Eschscholtz (F).
Galerus inornatus Gabb (F).
Glycymeris intermedia Broderip (F).
Hipponyx cranioides Carpenter (F).
Lacuna solidula Loven (E).
Lævicardium centifilosum Carpenter (F).
Lunatia lewisii Gould (E).
Macoma n. sp. (F).
Metis alta Conrad (E).
Mitra maura Swainson (E).
Modiolus rectus Conrad (E).
Monoceros lugubre Sowerby (F).
Murex monoceros Sowerby (F).
Nassa californiana Conrad (E).
Nassa perpinguis Hinds (E).
Nassa mendica var. cooperi Forbes (F).
Neptunea altispira Gabb (E).
Olivella intorta Carpenter (E).
Panopea generosa Gould (E).
Psephis tantilla Gould (E).
Semele n. sp. (E).
Solen rosaceus Carpenter (E, F).
Siliquaria edentula Gabb (F).
Spisula planulata Conrad (E).
Tellina idæ Dall (E).
Tresus nuttalli Conrad (E).
Triton gibbosus Broderip (E).
Turritella jewetti Carpenter (E) (Pl. XLI, fig. 15).
Turbonilla sp. (F).

SOUTHEASTERN FLANKS OF MOUNT SAN CAYETANO.[b]

Arca cf. labiata Sowerby.
Bittium cf. asperum Gabb.
Nassa perpinguis Hinds.
Calliostoma or Margarita sp.

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[a] Collected by W. L. Watts; identified by J. G. Cooper; listed in Bull. California State Mining Bureau, No. 11, 1897, pp. 81-83.

[b] Collected by the writer; identified by Ralph Arnold.

Cardium cf. quadrigenarium Conrad (?).
Crepidula cf. rugosa Nuttall.
Lacuna (?) sp.
Leda sp.
Macoma sp.
Modiolus (?).
Olivella sp.
Pholadidea cf. penita Conrad.
Psephis cf. lordi Carpenter.
Saxidomus gracilis Gould.
Siliqua patula Dixon (?).
Tapes staminea Conrad.
Tresus nuttalli Conrad (?).
Turritella cooperi Carpenter (Pl. XLI, fig. 14).
Yoldia (?) sp.

BARLOW'S RANCH, 3 MILES EAST OF VENTURA.[a]

Acmæa pelta Eschscholtz.
Actæon (Rictaxis) punctocœlata Carpenter.
Angulus buttoni Dall.
Anomia lampe Gray.
Balanus concavus Bronn.
Bittium asperum Gabb.
Cadulus fusiformis Sharp and Pilsbry.
Cancellaria tritonidea Gabb.
Chione succincta Valenciennes.
Chlorostoma funebrale A. Adams.
Chorus belcheri Hinds.
Columbella (Astyris) gausapata Gould.
Columbella (Astyris) gausapata, var. carinata Hinds.
Crepidula adunca Sowerby.
Cryptomya californica Conrad.
Cylichna alba Brown.
Dentalium hexagonum Sowerby.
Donax lævigata Deshayes.
Drillia hemphilli Stearns.
Drillia inermis Hinds.
Drillia inermis var. penicillata Carpenter.
Echinarachinius excentricus Eschscholtz.
Eulima micans Carpenter.
Eulima hastata Sowerby.
Lacuna compacta Carpenter.
Littorina scutulata Gould.
Macoma nasuta Conrad.
Mactra catilliformis Conrad.
Mangilia angulata Carpenter.
Modiolus fornicatus Carpenter.
Monoceros engonatum Conrad.
Nassa californianum Conrad.
Nassa fossata Gould.
Nassa mendica Gould.
Nassa perpinguis Hinds.

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[a] Arnold, Ralph, The paleontology and stratigraphy of the marine Pliocene and Pleistocene of San Pedro, Cal.: Mem. California Acad. Sci., vol. 3, 1902, p. 55.

Neverita recluziana Petit.
Neverita recluziana var. alta Dall.
Odostomia gouldii Carpenter.
Odostomia nuciformis var. avellana Carpenter.
Odostomia tenuis Carpenter.
Olivella biplicata Sowerby.
Olivella intorta Carpenter.
Olivella pedroana Conrad.
Pecten latiauritus var. monotimeris Conrad.
Saxidomus aratus Gould.
Scala crebricostata Carpenter.
Scala tincta Carpenter.
Tapes tenerrima Carpenter.
Terebra simplex Carpenter.
Tornatina culcitella Gould.
Tornatina harpa Dall.
Turritella cooperi Carpenter (Pl. XLI, fig. 14).
Turbonilla laminata Carpenter.
Turbonilla, four sp. (?).
Yoldia cooperi Gabb.

PLEISTOCENE DEPOSITS.

DEPOSITS IN THE VICINITY OF SAUGUS.

The low hills that border the broad, open valley of Santa Clara River in the vicinity of Saugus are covered by a prominent body of gravel, sand, and arenaceous clay, the gravel largely predominating. The coarser material is mostly composed of granite, derived, probably, from the San Gabriel Range. Traces of other rocks, however, are included with the granite, and the whole is loosely cemented together. The beds have a general dip of 2° to 10° toward the center of the valley. The thickness of the terrane is undetermined. Above the level of the valley perhaps 300 or 400 feet are exposed, but below the valley the extent of the formation is not known. These beds are probably of fresh-water origin and, though they have yielded no fossils whatever, their unconformable position on the Fernando suggests late Pleistocene as the time of their deposition.

DEPOSIT AT MOUTH OF SESPE CANYON.

At one point overlooking Sespe Creek there is a cut bluff showing bright-red sediments of apparently the same materials as those just described. The deposit was not examined in detail. It may prove to be a remnant of the Sespe formation or a portion of the Pleistocene that is composed of red material derived from the Sespe.

CONGLOMERATE OF LION CANYON.

In the vicinity of the Lion Canyon wells is a conglomerate that has not hitherto been recognized at any point in the Ojai Valley, nor, indeed, elsewhere in the ranges that border the Santa Clara. Its

leading feature is the contained bowlders of sandstone, differing but slightly in composition from the matrix or body of the rock itself. It appears only in the limited area between the Sespe and Modelo formations. A somewhat similar occurrence is found at the east end of the Upper Ojai Valley, where Sisar Creek leads out from it. The stratigraphic relations of this rock are uncertain, but its composition suggests that it may be the remnant of a Recent formation of bowlder sand which here and there skirts the Upper Ojai Valley, forming along its northern side, locally, extensive benches. In the region of the Lion Canyon wells the rock is impregnated with bitumen, and seepages spring from it. It is penetrated by the wells, but it is believed that they derive their oil from the underlying formation.

GENERAL STRUCTURE OF DISTRICT.

INTRODUCTORY STATEMENT.

It has been deemed expedient to divide the discussion of the structure of the region bordering the Santa Clara Valley into two sections. The first, embracing a brief exposition of the more important features, is included in the pages immediately following. The second, dealing with those details so essential for purposes of practical application, is subdivided, each portion being included in the description of the territory to which it refers. It may be well to call the reader's attention to the general sections on Pls. III and IV. These sections, together with the structural features depicted on the map (Pl. I, pocket), will doubtless more vividly portray the writer's interpretation of the structure than many chapters of descriptive text.

SANTA CLARA VALLEY.

The structure of the rocks underlying the Santa Clara Valley is perplexing. For several miles below Saugus the great body of younger conglomerate, sandstone, and clay of the Fernando formation passes diagonally across the bottom lands into the hills on either side, maintaining a strike of N. 50°-60° W. and a dip of 25°-50° NE. Within this area there is no apparent break in the regularity of the stratigraphic succession. From the mouth of Salt Creek westward, however, the hill formations become more and more folded, or even faulted, while the continuity of structure between the two sides of the valley is interrupted by a broad belt of river gravel. Lithologic similarity of both Miocene and Pliocene sediments at the several horizons adds still further to the difficulties attending a correct interpretation of the geologic conditions. The great mass of evidence suggests an enormous fault along the valley in the region north of South Mountain, the displacement dying out as it passes up the river. Final interpretation of the valley structure has, however, been reserved for a time when the general geology of the region shall be the primary object of investigation. The strip of enigmatical territory occupied by the valley therefore forms an obviously ideal line of division between the two more or less structurally distinct areas north and south of it, and advantage will be taken of this fact to discuss each of these areas separately.

REGION NORTH OF THE SANTA CLARA.

Of the great mountain system north of the Santa Clara Valley the southern member, the Topatopa Range, is alone involved in the geology of the developed oil fields. This range is 30 or 40 miles long; its trend is east and west; its structure is anticlinal, the axis passing a few miles north of the area mapped in Pls. I and V.

In the region of Sespe Creek the axis of the anticline lies beneath the crest of the range and is occupied by characteristic quartzites and slates to which has been assigned the name Topatopa formation. The anticline is symmetrical and is well displayed in the canyon walls. About the Topatopa formation bend in succession the Sespe, Vaqueros, Modelo, and Fernando beds, all strongly developed and forming conspicuous features of the landscape. Toward the east the point of the anticline broadens, the Modelo sandstone outcropping in a wide sweep about the axis and the youngest beds covering a still greater area in their arch. The west end of this great anticline has not been located, the consideration of its east end being sufficient for the purposes of the present report.

The northern side of the anticline is unexplored, and whether the prominent ridge of granite lying to the north is produced by faulting or is a part of a separate dynamic system is unknown.

The southern limb of the anticline presents an intricate succession of secondary folds and accompanying faults that extend from Ventura River and the Ojai Valley beyond Piru Creek. East of Santa Paula Creek the strata are strongly bowed to the south. At Sespe Creek the curvature is as pronounced in the opposite direction. Immediately west of Hopper Canyon the convex side of the bend is again to the south, while east of Piru Creek regularity of trend is once more approximately resumed. North and east of the Ojai Valley the south limb of the Topatopa anticline is overturned.

An examination of the map makes it obvious that faults are the dominant structural feature in the Ojai Valley, at the west end of the territory under discussion. No less than five fractures cross the region from east to west, divergent in trend from N. 60° W. at the north to S. 75° W. at the south. The result has been a succession of interfault blocks more or less limited in size, with considerable variation in the strata opposed. The faults originated nearly at a common center in the great fracture passing in front of San Cayetano Moun-

tain. The northernmost fault lies between the rusty Vaqueros beds and the Modelo shale. South of this is the second fracture of the system, the block between them being composed of Modelo shale. Between the second and third faults, the latter passing immediately north of Lion Ridge, is a narrow block of rusty beds of the Vaqueros type. South of this is a comparatively broad zone of the Sespe formation, which in turn is separated from the Modelo shale, constituting Sulphur Mountain, by one of the most extensive faults of the region. South of Sulphur Mountain there is a fifth fault, marked by a line of seepages and oil wells. The evidence of faulting, however, must not be confused with the unconformity which exists between the Modelo and the Fernando. The shale of Sulphur Mountain is considerably crumpled, at least two marked anticlines (one of which is locally overturned) and the intervening syncline being present through nearly its whole length. The conglomerate, sand, and shale of the Fernando formation, south of their contact with the Modelo shale of Sulphur Mountain, maintain a southerly dip with marked persistency, at most varied only by minor and localized flexures.

The structural features west of Santa Paula Creek continue to the east for 4 or 5 miles, in front of Santa Paula Ridge and San Cayetano Mountain, but the faults terminate one by one or coalesce, until at the easterly apex of the region the disappearance of interfault blocks has brought the late Tertiaries into contact with the much earlier Topatopa formation, the great San Cayetano fault alone separating them.

In the Sespe district it is to be observed that the formations enter the Camulos quadrangle at its northern border from their passage around the east end of the axis of the Topatopa anticline, which lies between 1 and 2 miles to the north. Within the quadrangle crumpling begins near its northern border—at first gentle, then severe. The major features resulting from this movement are the Coldwater anticline, southeast of the broad table of red beds, and still farther south the syncline, whose eastern extension passes through the summit of Oat Mountain. South of the western part of this syncline is the great northward-dipping monocline of Topatopa beds on the north flank of Mount San Cayetano. Near the mouth of Sespe Canyon the beds are greatly disturbed by the close approach of the San Cayetano fault and the syncline just mentioned.

In the region east of Sespe Creek the more important of the subordinate or secondary folds include a partially overturned anticline southwest of Hopper Mountain; the Oat Mountain syncline, already referred to; an anticline that crosses lower Pole Canyon at its sharp turn from south to west, and another anticline a mile farther south. Each of these folds is a conspicuous feature of the geology from one or another point of view, but the syncline is perhaps the most marked, involving, as it does, the strata from the upper Modelo shale to the red beds of the Sespe. In addition to these, there are numerous local folds and one or two faults, each of which is of almost equal import ance to the features first mentioned.

Both Hopper and Piru canyons, in the lower 10 miles, have been developed across the structure at points where the strata are extensively puckered, each canyon lying a little east of the axis of a sharp strike flexure. The western of the two axes presents a change in trend from N. 65°–70° W. to N. 50°–70° E. The easterly axis shows a reverse change from N. 60° E. through east-west to N. 80° W. Locally slight departures from the general trend are to be found. For instance, the Modelo anticline and the syncline immediately to its south have a direction approximately east and west, and a number of minor folds between 1 mile and 2 miles in length, particularly conspicuous on the east side of Hopper Canyon, lie diagonally to the general trend of the larger flexures. Between the individual folds of the several trends direct continuity has not been established, but there is a suggestion of this in several instances, notably in the Oat Mountain syncline, which apparently can be traced from Sespe Creek nearly to the Modelo district, and again in the Lyons anticline, which almost certainly passes directly from the Piru Valley to Hopper Canyon. In any event, the folds are unquestionably the associated crumples of a single affected zone that passes continuously, though with wavy trend, from the region of Mount San Cayetano to that of Piru Creek.

Pl. III, sec. X–Z′, illustrates the general occurrence of petroleum in the mountains north of the Santa Clara Valley. The section without being continuous nevertheless represents in nearly their true succession the formations that occupy this great area and portrays the structural features that prevail in most of the productive oil territories. The line of the section is laid down on the map (Pl. I). Besides being somewhat irregular it presents two important offsets that were necessary to the generalization of the conditions. One of these offsets (x′–y) occurs at Little Sespe Creek and is a mile in length; the other (y′-z) embraces the interval between Brush Mountain and Piru Peak, a distance of 5 miles. In both intervals, however, the break in the stratigraphic succession is reduced to a minimum.

The formations involved include the Topatopa formation; the Sespe formation, with its three divisions—base, middle, and top; the Vaqueros formation, with its several bands of varicolored clays; the Modelo sandstones and their accompanying shales, a portion of which at least may correspond to the Monterey, and the Fernando formation, which probably extends from the Miocene through the Pliocene and well up into the Pleistocene. Their distribution over the line of the section may be gathered from the illustration. There are, however, certain features which it may be well to consider somewhat at length, for the reason that they have a bearing on the occurrence of petroleum.

The Topatopa anticline, shown at the left of the section, involves rocks of the Topatopa formation, which are proved to be more or less petroliferous by the seepages that occur on their outcrops and by the actual dissemination of bituminous matter through certain of the beds. There are, however, no wells that penetrate the formation, and its possibilities are as yet unknown. At the base of the Sespe formation there is a layer of white sandstone which, in the gorge of Sespe Creek, has been found to yield an excellent supply of low-gravity petroleum. The well of the Union Consolidated Oil Company penetrates the strata in this vicinity to a depth of approximately 500 or 600 feet. The position of this well, on the regular slope of the main Topatopa anticline, is of especial importance from the clew it may afford as to the occurrence of oil at this horizon under like conditions in other localities.

A second feature of importance is the Coldwater anticline. The strata on the northern face of this arch are productive, the oil being derived from about the same horizon as that of the well just mentioned, 2½ miles to the northwest. The longitudinal extent of this anticline in an easterly direction was not determined by the writer, but in Boulder Creek, a little more than a mile to the east, a somewhat similar fold appears nearly in the line of the Coldwater flexure. It may be, however, but an offset of the latter or a mere crumple on its flanks. It is indicated in the section and is the locus of the Ivers wells. Although conspicuous in the field, when plotted it is of comparative insignificance. The oil found at this point may have no relation to the minor fold, but, on the other hand, the fractures resulting from such a fold may have afforded a special opportunity for the accumulation of the petroleum.

One of the few occurrences of oil observed in California near the axis of a syncline is that seen at the Kentuck wells, which are located in a hollow of the Sespe red beds half a mile north of Little Sespe Canyon. The most plausible explanation of this exceptional occurrence is that it is due to the effects of the Coldwater anticline, or possibly even of the greater Topatopa anticline, the negative effects of the local syncline being insufficient to overcome the influence of the greater folds.

A short distance south of this depression the red sandstone of the Sespe formation dips steeply near the point where the axes of the folds exhibit a general change in strike from northeast to southeast. The locality is one of marked crushing and its structure is most difficult to decipher. The offset of a mile in the section was made here, the strata being again taken up in regular succession in the vicinity of the

Foot-of-the-Hill wells. From this locality to the top of Brush Mountain the series of rocks from the upper members of the red sandstones of the Sespe through the rusty beds at their summit and the great mass of shale that makes up the Vaqueros formation is unbroken. Three oil-bearing horizons have been found within this range—one either at the summit of the red beds or the base of the rusty member of the Sespe; another perhaps in the purple clay of the Vaqueros formation, and a third in the upper, earthy, and siliceous portion of the Vaqueros, not far below the Modelo sandstone. The wells are to be regarded as located on the slope of the general Topatopa anticline, for a careful examination of the locality reveals only minor and very insignificant crumples in the general sweep of the beds in an easterly, northeasterly, and northerly curve about the axis of the main fold.

Brush Mountain is capped by the lower Modelo sandstone and a thin band of the overlying siliceous shale. The second offset in the general section occurs at this point. On Piru Peak very nearly the same formations are encountered, the only difference being a somewhat greater amount of the siliceous shale at the top of the series. The lower Modelo sandstone outcrops immediately beneath the shale and at the head of Modelo Canyon is affected by the Modelo anticline, which is one of the most conspicuous and perfect folds of this character to be found anywhere in the region under discussion. The sandstone here, however, appears to be at least several hundred feet thick—thicker, indeed, than on Brush Mountain, and yet by no means so extensively developed as about the head of Hopper Canyon, farther north. The succession of strata on the two sides of the anticline varies somewhat, but this is perhaps due to crumpling and faulting. The presence of a fault is indicated by the abnormal succession of beds encountered in crossing the outcrop of the formation. It is probable that at the line of this section the opposing beds for some distance from the surface belong to the shale between the upper and lower Modelo sandstones, but the exact amount of throw is indeterminable, first, because of the uniformity of the shale in appearance; second, because of the rapid variation in the thickness of the strata, and third, because of the crushing that has taken place adjacent to the fracture.

The Modelo anticline is one of the most productive folds north of the Santa Clara Valley. About midway of the folds are the wells of the Modelo Oil Company, attaining a maximum depth of about 1,800 feet, with oil at 1,400 or 1,500 feet and indications of oil at still greater depths below the surface. The wells are wholly in the Modelo sandstone, which in places is so free from shale and so solid as to stand without casing. The wells are drilled in strata that dip 60° or more on both sides of the anticline, at distances varying from less than 100 feet to 600 or 700 feet on each side of the axis. The wells of the Sunset Oil Company in Hopper Canyon, 1½ miles to the west, are also on this fold. They have produced some oil, but have not been operated with the same care as the wells of the Modelo Oil Company, and as a consequence much water occurs with the oil.

The Nigger anticline lies a mile and a quarter south of the Modelo fold, being separated from it by a syncline and the fault already described. The strata involved are the upper Modelo sandstone and the shales above and below. The productive wells on this anticline are in the easterly tributary of Nigger Canyon, a little south of the axis of the fold. They are 500 or 600 feet deep, the oil having been encountered at depths of 65 to 400 feet.

Half a mile south of the Nigger anticline is a sharp change in the rocks which represents the contact between the Modelo and the Fernando formations. The younger beds have a northerly dip, which represents either an overturn at the plane of unconformity or a fault—perhaps both. That an unconformity exists between the Fernando formation and the underlying beds is beyond doubt, and many strata are brought successively into contact on either side of the plane. From the point of the ridge separating Nigger Canyon from Piru Creek eastward for several miles beyond this stream there is a marked line of disturbance. A synclinal structure has been suspected, but careful examination indicates that this supposition may have been induced by the deceptive relations of the dips; in reality there is probably an anticline, with a very steeply inclined southern limb, which west of Piru Creek has possibly been the locus of a fault. At this point in the section, therefore, there may be a fault in proximity to a line of unconformity, much after the order of the unconformity and fault passing along the southern border of the Puente Hills from the region of the Santa Fe wells westward to Whittier. (See p. 111.) Doubtless the dip of the Fernando strata changes from northerly to southerly beneath the valley of the Santa Clara, but exposures along the bottom lands are wanting, and the relation of the formations north of the river to those south of it can only be conjectured.

REGION SOUTH OF THE SANTA CLARA.

The mountains bordering the Santa Clara Valley on the south represent the west end of one of the most important uplifts of southern California. The center of uplift, the San Gabriel Range, consists of granites and related rocks. Encircling these on the west are sedimentary beds of Tertiary age, which constitute, in the order named from east to west, the lower elevations of the Santa Susana Mountains, Oak Ridge, and South Mountain. The structure of this system of ridges is anticlinal and notwithstanding a degree of continuity between the formations north and south of the upper portion of the Santa Clara Valley the mountains south of the river preserve, on the whole, remarkable independence of structure. In the western half of the system the structure is comparatively simple, consisting of a main anticlinal fold affected by a few subordinate wrinkles. In the eastern portion, however, although the effect of the uplift has been the production of a single range crest, there are, nevertheless, three distinct folds of a more or less secondary nature, arranged en échelon and slightly diagonal in trend to the course assumed by the general ridge system. These folds may be designated the Torrey, Tapo, and Pico. A fourth, en échelon with the others and known as the Elsmere, is in reality the western terminus of the San Gabriel uplift itself. Although secondary to the dominant structure these folds are well developed and are of especial importance in that they have become the loci of several very productive oil fields. There are numerous minor crumples and, along the southeastern crest of Oak Ridge and the southwestern face of the Santa Susana Mountains, at least one fault of considerable throw.

OIL FIELDS NORTH OF THE SANTA CLARA.

The oil fields north of Santa Clara River involve an area having an east-west length of 35 miles and a width of 7 to 15 miles. For convenience of discussion, this area may be divided into the Ojai Valley, Sulphur Mountain, Silver Thread or Sisar Creek, Santa Paula Ridge, Sespe, Pole Canyon, and Hopper-Piru fields. (See Pl. V.)

OJAI VALLEY FIELDS.

LOCATION.

The Ojai Valley fields comprise the region of the upper and lower valleys, lying between the Topatopa Range on the north and Sulphur Mountain on the south. Nordhoff, the only town within the district, lies about 15 miles north of Ventura, with which it is connected by a spur track of the Southern Pacific Company, and 12 miles northwest of Santa Paula.

STRUCTURE.

Pl. III, sec. A–A′ indicates in a very general manner the structural relations of the several formations exposed in this valley. The series of beds north of the Lower Ojai Valley is a part of the great overturned south flank of the anticline developed in the Topatopa Range. The overturning was accompanied by faulting. The delineation of the faults on the map (Pl. I) is highly generalized from the evidence afforded by soil coloring and isolated outcrops. They will be described in the order of their occurrence from north to south.

The succession of beds from the base of the Topatopa Range, or across Lower Ojai Valley, is perhaps without break. If so, there is an upper and a lower series of rusty beds separated by a broad belt,

between 1,000 and 2,000 feet thick, of red and white sandstones which seem to belong to the Sespe formation. Between the southerly belt of rusty beds, which are regarded as Vaqueros, and the Modelo shale, which constitutes Thompson Ridge, there is unquestionably a fault the throw of which can hardly be less than 2,000 feet. The Thompson Ridge fracture is more directly in line with the San Cayetano fault to the east than any of its associates and it may be responsible for the existence of both the Upper and Lower Ojai valleys. To the east it passes immediately south of the wells of the Bard and adjacent oil companies. Between the Lower Ojai Valley and Santa Paula Canyon the thickness of the red beds is greatly reduced, and to the south the rusty beds may almost entirely disappear, for in the Silver Thread district the outcrop of these two strata is less than 300 feet thick. From the trend of the formations north of the Lower Ojai and from lithologic similarities, it is inferred that the great development of rusty beds north of the Bard and Capital Crude wells is continuous with those of the Topatopa formation in the lower slopes of the Topatopa Range to the west. At this point these beds have furnished a fair collection of fossils, which are regarded as Eocene. In this connection it is worthy of notice that at the head of the Lower Ojai Valley the rusty beds south of the red beds carry fossils that were, with equal certainty, determined as lower Miocene.

The Modelo shale, forming Thompson Ridge, is severely crumpled and is probably an included fragment of siliceous shale. It disappears beneath the wash of the Lower Ojai Valley and has every evidence of wedging out a little west of the Silver Thread district.

South of this interfault block of Modelo there is a narrow band of rusty beds, which also wedge out to the east. These beds have every appearance of the Vaqueros formation and carry the same fossils as those north of the Modelo block. They border Thompson Ridge on the south and pass at once into the Lower Ojai Valley, where they disappear beneath the later wash. This block of rusty beds presents a variety of dips and strikes, and it is thought, therefore, to be simply an inclined fragment between the great faults of the region. The fracture separating it from the red beds bordering it on the south is recognized as passing the valley road at the head of the gorge between the Lower and Upper Ojai basins to the west, following the line of a short gulch to its junction with the general valley. It is probable that in this direction it has been the northern determinant of Lion Ridge. To the east the fault seems to pass in a direction about S. 80° E., merging finally with one or another of the greater fractures of the system.

It is interesting, also, to note the occurrence of a narrow strip of rusty beds included in the Modelo shale in the easterly portion of the crest of Thompson Ridge.

The red beds of the Sespe formation again become prominent in Lion Hill, which lies between the Lower Ojai and Lion Canyon to the south. This ridge is an anticline, the trend of its axis curving slightly from N. 87° W. at the west end to N. 70° E. at the east. The crown of the arch is but gently bowed. The flanks, however, show steeply inclined strata. Locally, a slight synclinal flexure appears. To the north the red beds pass beneath the wash of the Lower Ojai Valley; to the south they are succeeded by the Modelo shale of Sulphur Mountain, the line of division being practically coincident with the stream channel in Lion Canyon.

The Sespe formation of Lion Hill is doubtless another interfault block, more than ordinarily prominent, in the series that occupies the Ojai Valley. The apex of this block probably terminates within a mile of the Silver Thread district, the small body of red beds appearing in the latter region belonging to the greater mass of similar beds lying on the north side of the Ojai Valley. The Sespe formation in the block under discussion widens and becomes an important formation in the western portion of the Lower Ojai west of San Antonio Creek and Ventura River. On the north the red beds are in contact with the rusty beds in the minor interfault block already described, and, to the east of this block, with the projecting portion of the included fragment of the Modelo formation. On the south they are in contact with the Modelo shale throughout its whole length to San Antonio Creek. The minor interfault block of the Modelo in Thompson Ridge being disregarded, this Sespe block would appear to have been pushed up with reference to the formations north and south of it, particularly those on the north.

Along Lion Canyon and the south edge of the Upper Ojai Valley is another of the greater faults of the district. Like the others, however, it terminates near the common center in the vicinity of Santa Paula Canyon. Farther west it is probably of considerable extent, having been recognized, it is thought, at the canyon of Ventura River several miles below Nordhoff. In any event there is the same succession here that is encountered in the Ojai Valley.

Sulphur Mountain from one end to the other is composed of the Modelo shale, the strike of which corresponds with the trend of the ridge about N. 80° E. The dip is generally to the south. There are, however, local crumples of different degrees of importance, as, for instance, a possible anticline, indicated on the map (Pl. I) as passing along the lower slope of the mountain, and a second, the axis of which passes a little south of the well of the Langdell, Newmark & Roan Oil Company, a few hundred feet below the summit. Also, it is possible that faulting, as well as folding, has taken place within the confines of the mountain. Such folds and faults may be accountable for the lines of petroleum seepages on both the north and south sides of the ridge.

Sulphur Mountain itself is perhaps an interfault block, a possible fracture existing at the line of contact of the Modelo and Fernando formations south of the ridge, although the succession may be merely one of unconformity. The writer is inclined, however, to the view that a fault is present. The linear extent of the folds in Sulphur Mountain has not been determined. The east end of Sulphur Mountain presents a syncline at its crest, an anticline at its northern base coincident with the lower portion of Sisar Creek, and another anticline south of the mountain in the vicinity of the Adams Canyon oil wells.

There is an anticline south of the western portion of Sulphur Mountain showing in the road which descends from the summit to the upper part of the Cañada Larga. In the line of this anticline is a like fold at Ventura River, and it is possible that the two are continuous. Although the rocks involved in this fold belong mainly to the Modelo formation, gray and brown argillaceous shales and heavy sandstone, probably of the Fernando formation, lie immediately upon its southern flanks and locally may have become affected.

OIL WELLS.

The oil wells in the Ojai fields comprise those of the Union Oil Company on the Pirie ranch, at the west end of Lion Hill; two in Lion Canyon, about 1½ miles southeast of the Pirie wells; a couple drilled by Langdell, Newmark & Roan near the summit on the north slope of Sulphur Mountain, and a group along the northeastern side of the Upper Ojai, sunk by the Whidden-Double, Sobra Vista, and Santa Paula oil companies.

PIRIE RANCH WELLS.

Two groups of wells belonging to the Union Oil Company are located on the Pirie ranch south and southeast of Nordhoff, in the Lower Ojai Valley. The first group, consisting of three wells, is about a mile S. 25° E. of the town, on the west end of Lion Hill; the second group lies across a small valley, about three-fourths of a mile S. 70° W. of the first. All the wells penetrate the red beds of the Sespe formation, those of the first group being about 100 feet south of the axis of the Lion Hill anticline, and those of the second on the south limb of the same anticline, at least three-eighths of a mile south of its axis. At the time of the writer's visit the wells were abandoned and only one derrick was standing. It was learned, however, that black oil accompanied by considerable quantities of gas was struck in the wells of the first group, and that for a time they were pumped. Gas was heard rumbling in one of the holes and another contained water. No seepages were noticed in the locality of the wells.

Five wells constitute the second group, four close together and a fifth about one-fourth mile to the southwest. The deepest of the four is about 1,500 feet deep. A little oil was encountered at 30 feet and some also at about 400 feet; for a time considerable oil and water, mostly the latter, were pumped. In another well thick oil was struck at 100 feet and a lighter oil at 333 feet, thus indicating at least two oil-bearing strata for this locality. Much water was found in the westernmost well and it was abandoned before reaching the oil sands.

LION CANYON WELLS.

Two wells, now abandoned, were sunk in Lion Canyon about 2¼ miles southeast of Nordhoff. They are situated in the brown shale of the Modelo formation, not far south of the fault separating the shale from the Sespe red beds of Lion Hill. The wells lie in line with what to the east is a faulted overturn, but which here may be only a simple anticline. Heavy oil stands in the eastern well at a depth of about 200 feet, while a lighter emulsion of oil and water rises to about the same level in the western well. Some of the oil which had been bailed out and was standing in a barrel had a gravity of about 16° B. It was black and ran quite freely, though stringing some.

LANGDELL, NEWMARK & ROAN WELLS.

The two abandoned wells of this company are located on the north slope of Sulphur Mountain, only a short distance below its crest and just west of the road leading up from the Upper Ojai Valley. The holes are sunk a little north of the anticlinal axis, which passes immediately north of the summit of the mountain, and penetrate the brown and gray shales of the Modelo formation. The higher well is located at the upper edge of a prominent oil seepage; it is said that a little light oil was struck at about 800 feet and that the well was abandoned in a white clayey shale at 1,000 feet. The lower well was sunk right in the seepage, but yielded nothing. The natural seepage of oil at the wells is claimed to be about a barrel a day.

WHIDDEN-DOUBLE WELLS.

The five wells of the Whidden-Double Oil Company are located in the Modelo shale fault block on the northern side of the head of the Upper Ojai Valley. The surface outcrops here show a slight northerly dip, while the well logs indicate a much steeper dip to the northeast for the oil sand. The structural relations in the vicinity are somewhat complex, but it seems likely that the wells are situated on the north flank of an anticline more or less complicated by minor folds. It is reported that the holes vary in depth from 132 to about 950 feet and that they yield oil of 8° to 15° gravity. The petroleum is black and in two of the wells is associated with more or less water. The deepest well is said to penetrate two sands, the lower of the two yielding the lighter oil. An interesting fact is that No. 3, one of the shallower wells, although having a greater initial production than No. 5, which was deeper, did not hold out nearly so well. The yield of the wells was never very great and they were finally abandoned in 1904.

SOBRA VISTA WELLS.

The Sobra Vista wells, three in number, are located at the head of the Upper Ojai Valley, immediately south of the Whidden-Double property. As indicated by the structure in the immediate vicinity, the wells are probably located on the north flank of the local anticline which is so well developed in the region of the Santa Paula group of wells immediately to the west. The strata penetrated are the blue and gray shales of the Modelo formation, here containing interbedded sands from which, it is said, the wells derive their oil. In fact, the southernmost well of the group is located precisely on the line of strike of the sandstone which affords the heavy oil seepages on the Santa Paula property. The wells range in depth from about 375 to 740 feet and obtain their oil from two sands about 240 feet apart, the upper varying from 10 to 11 feet and the lower from 4 to 11 feet in thickness. It is said that an 11-foot stratum of black water sand was encountered between the oil sands in one of the wells, and that in

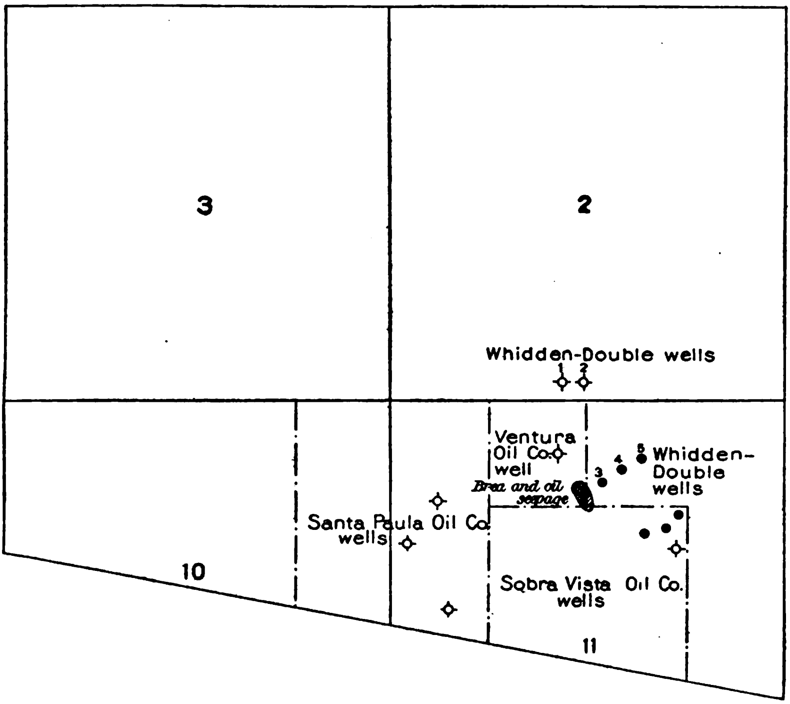


FIG. 4.—Sketch map showing location of wells and oil seepages in the northeast corner of the Upper Ojai Valley. Heavy black dots, wells abandoned since beginning of 1902; the other symbol, wells abandoned previous to 1902.

another the drill was stopped in a deposit of tar too heavy to pump. The best well is reported to have started with a yield of 50 barrels per day, but this was reduced to about 13 barrels at the time of the writer's visit (1902), and still later is stated to have fallen off considerably more. The oil is black and heavy and is said to run 48 per cent of exceptionally pure (92 per cent) asphaltum.

SANTA PAULA WELLS.

Immediately west of the Sobra Vista group, at the head of the Upper Ojai Valley, are the two wells of the Santa Paula Oil Company. They penetrate the blue shale of the Modelo formation, which is here folded into a westward-plunging anticline. The wells derive their oil from interbedded sandstones, some of which yield seepages of heavy asphaltum. The northern well is farther down the dip and is the deeper of the two. It is reported that this yielded lighter oil than the southern well and that the latter struck oil similar to that encountered in one of the Sobra Vista wells, which was too heavy to pump.

SOUTHERN SULPHUR MOUNTAIN FIELD.

LOCATION.

The oil areas that have been developed along the southern base of Sulphur Mountain lie at the heads of Aliso, Wheeler, Salt Marsh, and Adams canyons and along the short gulch heading against Adams Canyon from the Santa Paula Valley. All are a short distance south of the northern boundary of what once constituted the San Buenaventura Mission. The general elevation of these areas is about 1,100 feet, Sulphur Mountain rising abruptly above to heights between 2,500 and 2,750 feet. The canyons are of easy grade and the intervening ridges are comparatively low.

GEOLOGY.

Two and perhaps three formations are involved in this field—Modelo shales; Fernando conglomerate, sandstone, and clay; and possibly certain remnants of the Pleistocene, consisting of coarse gravel and gritty sand.

The Modelo is confined to Sulphur Mountain and consists of blue and brown, finely laminated shale, which is either earthy or siliceous, here and there even slightly sandy, and thin beds of sandstone. The shale is the conspicuous feature, however, and is of the type variety. It carries the customary gray to yellow limestone concretions, which with the shale show an abundance of organic remains, foraminifera and fish integuments and their impressions. The browner variety of the shale is gypsiferous and carbonaceous.

Adjacent to the line of division between this shale and the succeeding formation there is in places a body of earthy shale, the general color of which is brown and through which are threaded thin-bedded sandstones from a few inches to a few feet in thickness. All in all, this shale somewhat resembles others of doubtful age that are encountered in the oil fields of the Santa Susana Mountains and is not unlike certain beds that underlie the more siliceous shale of the Modelo formation in the region of Hopper Canyon. The question regarding the beds referred to in the Santa Susana Mountains is whether the shale actually belongs to the Modelo or to a younger formation, although perhaps still of Miocene age. The same uncertainty holds for the shale of the Sulphur Mountain localities until detailed work shall have determined its proper reference. A possible characteristic that may prove to be of value in distinguishing this shale from those of the Modelo, the more finely laminated beds of which are of a like brown color, is the mud-like texture and consistency of the younger shales. The younger clays are, moreover, decidedly arenaceous, and are also commonly associated with sandstones.

The formation regarded as Fernando forms the mass of the hills between Santa Clara River and Sulphur Mountain, except, perhaps, a Pleistocene fringe along the immediate valley. Some of the lower sands are bituminous, this characteristic appearing to become more conspicuous as Sulphur Mountain is approached. The clays associated with the lower sands are brown or blue. The conglomerates of this series include pebbles of sandstone, quartz, granite, black chert, and siliceous shale, the last evidently derived from the Modelo and probably from Sulphur Mountain itself. The succession of beds here described is encountered also, though with some variation, in the Santa Paula Valley and in the several canyons to the west of Adams Canyon.

By reason of the uncertainty regarding the age of the brown shale referred to above it is evident that the line between the Fernando and the Modelo formation is indefinite. It is worthy of note in passing that there is a considerable difference in the gravity of the oils derived from the Modelo shales and the Fernando sands and gravels in this field, that from the Modelo being much the lighter.

Deposits of sand and coarse gravel occurring in the lower portion of Adams Canyon are doubtfully referred to the Pleistocene series. These have the appearance of being an outlier of the more prominent body of like sediments east of the Santa Paula Valley. The deposits have, however, received but passing attention and have little or no bearing on the geology of the Sulphur Mountain oil district.

STRUCTURE.

Secs. A–A′ and B–B′, Pl. III, show the probable structural relations of the different formations in the Sulphur Mountain region. The relation between the Modelo shale and the succeeding formation along the southern base of Sulphur Mountain is primarily that of unconformity, but faults are here and there suggested by the sharp contrast of the beds in contact and by the flexures that have particularly affected the strata in proximity to the line of the suspected fracture. The fault, if it exists, is in harmony with the other structural features of the region and is supplemental to those farther north already described. It is the southernmost component of the system radiating from the San Cayetano fracture a mile or two east of the Santa Paula Valley. In each of the canyons in the southern face of Sulphur Mountain evidences of the fracture are more or less distinct.

Of the flexures in the area under discussion the sharpest occur in the interfault block of the Modelo shale. The most conspicuous one occurs halfway up the face of Sulphur Mountain. It consists of a zone of severely crushed strata 100 to 200 feet broad.

A short distance south of the suspected fault, in the younger formation of clay, sandstone, and conglomerate that is possibly the Fernando, there may be here and there detected an anticlinal fold, its axis having the general strike of the formation, varying from N. 65° E. at the eastern terminus of the mountain to N. 80° E. farther west. The southern limb of the anticline extends beneath the foothills to the Santa Clara Valley, the dip varying from 45° to 80°, but usually approaching the lesser angle. The northern limb is steep, short, and truncated by the plane of the fault. This structure appears in several of the canyons and hill areas, but its continuity from point to point has not been established. Instead of an anticline it may be, perhaps, but a bending downward of the strata, a crumpling of the beds due to compression adjacent to the fracture. In Adams and Wheeler canyons the anticlinal feature is somewhat stronger, while in Aliso Canyon general crumpling seems to prevail. Farther west, however, in the region of Harmon Canyon, the anticline again appears; the northern limb is still short and terminates in a sharp reverse flexure, or perhaps at the fault, which marks the junction of a series of table-like benches with the main body of the mountain. The entire region north of this fault to the Topatopa Range is a succession of displaced blocks, crumpled in the manner just described. From the axis of this disturbance southward to the Santa Clara Valley the strata maintain their southerly dip with marked persistency, at most varying only by minor and localized flexures.

OIL WELLS.

The line of the suspected fault along the south side of Sulphur Mountain is marked in the several canyons by many strong seepages of petroleum, and in proximity to the fracture, in the northward dipping or more severely crumpled strata of the Fernando formation, most if not all of the wells of this general field are drilled. Those yielding the lighter oil, however, may penetrate to minor sands in the Modelo, or they may be peculiar to the brown shale of uncertain though perhaps Modelo age (p. 19). The heavier oil without doubt occurs in the Fernando formation.

The wells in the field under discussion have been drilled at the heads of Aliso, Wheeler, Salt Marsh, and Adams canyons and along the bottom of a short gulch east of Adams Canyon. But little new development was under way at the time of the investigation and it was difficult to obtain data relating to the occurrence of the petroleum. Furthermore, many of the wells were old and were abandoned, while the product of others was reduced to only 1 or 2 barrels a day. The initial flow of some of the wells appears to have been as high as 25 or even 50 barrels. The depth as a rule ranges between 150 and 500 feet, but here and there 1,800 or 2,000 feet is said to have been attained. An early mode of recovering the oil was by tunnels, many of which penetrate the shale of Sulphur Mountain. From these a small amount of oil still seeps, although several barrels a day have been obtained.

Two varieties of oil occur in this field—one black, with a gravity of 19° to 30° B.; the other green, with a gravity of 30° to 32° B. The lighter oil, as already stated, is believed to be associated with the shale doubtfully assigned to the Modelo formation. It occurs nearer the base of the mountain than the black and heavy oil. The comparatively shallow depth of certain of the wells yielding green oil and their location well up on the slopes of Sulphur Mountain suggest the possibility that the productive beds outcrop in the base of the mountain. None of the strata, however, so far as the writer could learn, showed any indication of containing petroleum.

The duration or life of the wells varies. Two years seems to be the maximum for the larger yields, but beyond this time the product dwindles to 1 or 2 barrels a day and then remains constant for an indefinite time. This constancy, coupled with the inexpensiveness of pumping, accounts for their still remaining in service. The earliest drilling reported in this field was done by Mr. Adams twenty-five years ago in Adams Canyon. This well and another in proximity, put down by the Union Oil Company, afforded a light oil, and a similar product was obtained by wells in Salt Marsh Canyon. Periodic attempts have been made to develop the source from which this supply was derived, but without success. Opinions differ as to the relations of the light oil to the Modelo shale. It is possible that this oil is derived from the strata adjacent to the shallow wells (about 200 feet deep) which are probably in the Modelo shale; but on the other hand, the beds are severely crushed and the oil may be derived from a considerable depth, rising through fissures in the shale. Of the wells in Salt Marsh Canyon, one yielding green oil is said to have produced an average of 60 barrels a day after the head had been pumped off. It is said also that in the Salt Marsh wells the horizon affording green oil is first struck, the black variety being 100 or 200 feet lower down. In Wheeler Canyon the conditions are reversed, the top oil having a gravity of 28° B. and the lower, 400 or 500 feet below, of 30° B.

The dip of the strata in the several productive areas of this field varies from 45° to 80° N. South of the axis of folding and crumpling—south of the productive line, therefore—the dip is usually less than 45° S., although here and there 80° may be attained.

SILVER THREAD OR SISAR CREEK FIELD.

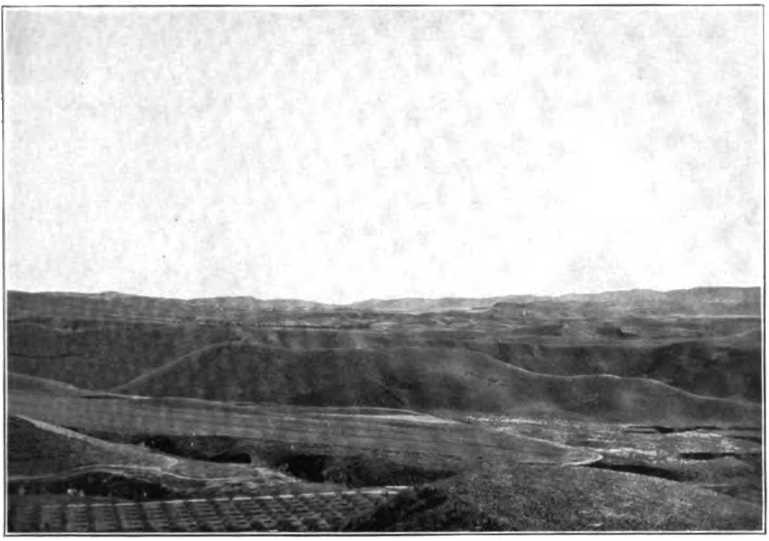
LOCATION.

The Silver Thread field is developed on the high ground immediately north of Sisar Creek, near its confluence with Santa Paula Creek, directly opposite the productive territory east of the latter stream. Pl. VI, *B*, shows its position in relation to the surrounding country.

STRUCTURE.

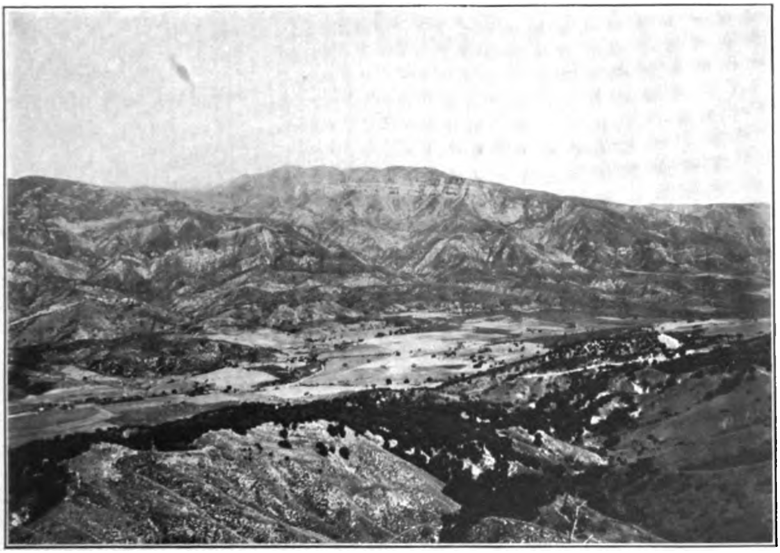
The field is included within the area of the great fault system extending from San Cayetano Mountain to the Ojai, and is therefore in structural relationship with the producing fields both west and east of it. It lies within a short distance of the point of convergence of the several faults that form so conspicuous a feature in the geology of this region. Pl. III, sec. B–B′, indicates the probable relations existing along this line through the field. The productive area lies in proximity to what is perhaps the principal fault of the Ojai system, which here passes along the steep slopes that form the northern walls of lower Sisar Canyon. The extent of the development is about a mile in length by 400 or 500 feet in width, the direction assumed by the wells being approximately S. 71° 45′ E., or about the trend of the line between the properties of the Bard Oil and Asphalt Company on the south and certain others on the north. The collars of the wells are but a short distance below the brow of the mesa that extends back to the main mass of the mountains on the north, being about 1,500 feet above sea level, or 500 feet above the bed of Santa Paula Canyon.

Only two or three formations outcrop in the Silver Thread field. The oldest of these, which occupies the northern portion of the belt, represents the upper part of the Topatopa and consists of a series of rusty conglomerate, sandstone, and shale, with interbedded quartz-



A. FLANKS OF OAK RIDGE AND SANTA SUSANNA MOUNTAINS, SHOWING POST-PLIOCENE PENEPLAIN.

From mouth of Sulphur Canyon; looking east.



B. THE UPPER OJAI VALLEY.

From crest of Sulphur Mountain, Ventura County

ose limestones, which carry fossils that have been determined to be Eocene. These rusty beds are a part of the overturned south flank of the great anticline to the north, and pass directly beneath the great body of older Topatopa quartzite and shale that occupies the very heart of the range.

The red beds, probably belonging to the Sespe formation, are exposed in a narrow belt little more than 100 yards wide, along the upper portion of the face of the ridge north of Sisar Canyon. They outcrop south of the rusty beds, passing beneath them, however, with a northerly dip, as part of the overturned series. They consist of coarse sandstone, streaked red and white, and shale colored in like manner, as in the Sespe region. In the Silver Thread field, as well as in the Ojai Valley, there is, stratigraphically below the red beds, a conspicuous layer of white sandstone from 20 to 30 feet thick, which is locally bituminous and carries small lenticular bodies of green and purplish clay. Stratigraphically above the red beds in the Ojai Valley are rusty beds, but these are not exposed in the Silver Thread region.

South of the red beds is the Modelo shale, occupying the slopes of Sisar Canyon and Sulphur Mountain. The formation here has the typical appearance, consisting of earthy to siliceous shale, brown, gray, and white in color, more or less organic, impregnated with gypsum, sulphur, and bitumen, and carrying lenses of limestone that weather a bright yellow. This shale is thrust down against the formations already described by a displacement, which may be called the Silver Thread fault. This is probably the principal westerly branch of the San Cayetano break and may be the continuation of the principal fault of the Ojai Valley. If this connection is correct, the displacement amounts probably to several thousand feet. Immediately south of the fracture the beds are folded into an anticline, the axis of which is coincident with the lower part of Sisar Canyon. In Sulphur Mountain they lie in a syncline, the axis being coincident with the crest of the mountain. A little farther south there is a second anticline, beyond which, with the exception of minor flexures, the southerly dip of the strata is maintained to the valley of Santa Clara River.

In the bluffs of Santa Paula Canyon, at the base of the oil-yielding hills, there is immediately north of the anticlinal axis an outcrop of 200 or 300 feet of earthy, micaceo-quartzitic shale, chalky in color and bearing yellow to gray limestone concretions and thin beds of sandstone. This shale resembles the chalky Modelo shale in Hopper Canyon and is probably its equivalent. Immediately south of the anticlinal axis, at the mouth of Sisar Creek, the more siliceous shale sets in. It is possible, therefore, that some faulting has taken place along the crest of the fold, so that the series is not the same on both sides. On the other hand, it may be that the appearance of the shale of northerly dip has been altered by the crushing that it has undergone in proximity to the fault.

The Modelo shale of Sulphur Mountain and the valleys north and south is continued east of Santa Paula Canyon in the foothills of the Santa Paula Ridge and San Cayetano Mountain; finally, by the convergence of faults, wedging out between the Fernando sediments of the foothills and the Topatopa formation of the mountain.

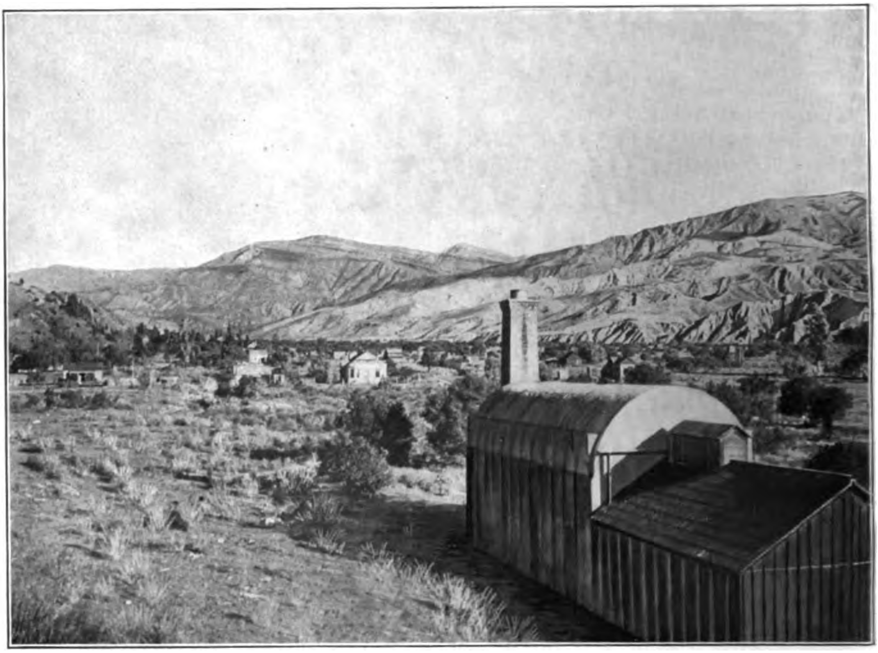
The general strike of the formations north of the Modelo is N. 65° W., the dip being 40°–70° N. Adjacent to the Silver Thread fault line the Modelo also strikes N. 65° W. parallel with the break, but along Sisar Creek the direction changes to nearly east and west, while south of Sulphur Mountain it is N. 60°–70° E. Immediately south of the main fracture the shale of this formation dips to the north, toward the plane of displacement, the axis of the adjacent anticline lying perhaps 200 or 300 yards farther south.

Although the prevailing dip near the Silver Thread fault is northward, the strata, nevertheless, present more or less irregularity of occurrence, the appearance suggesting a fragmental condition of the formations. This may readily be the case along a fracture of such proportions, the amount of displacement being hardly less than 5,000 or 6,000 feet.

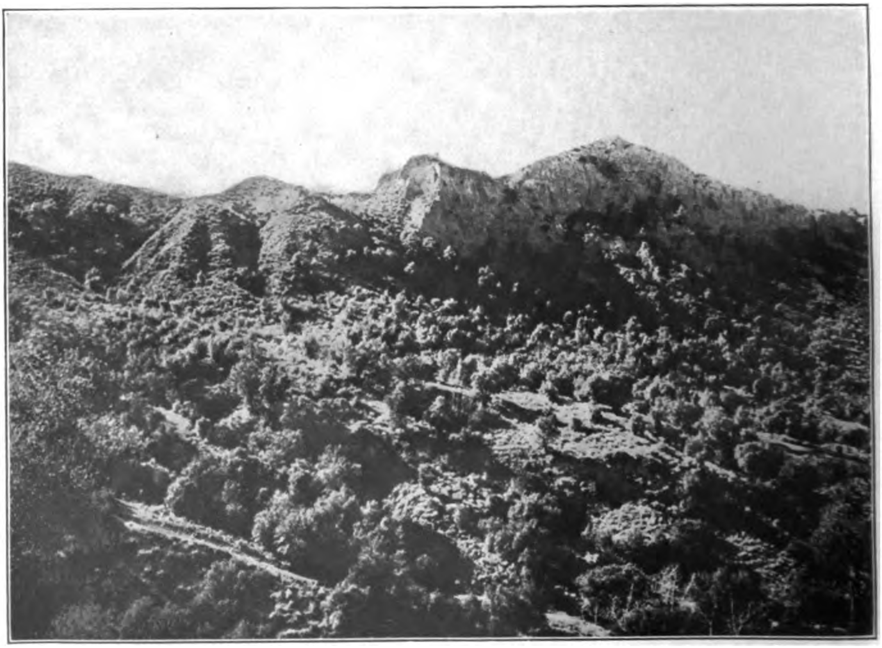
OIL WELLS.

The oil wells of this district all lie immediately north of the Silver Thread fault, which separates the Modelo shale and the Sespe red beds. They pierce the red beds, and a few wells in their upper portions pass through the more southerly members of the older but overlying rusty beds that carry Eocene fossils. None of the wells is distant more than 200 or 300 feet from the plane of fracture, while one or two are especially close to it, appearing, indeed, to have been sunk in crushed rock of the Modelo formation; however, in view of the uncertainty as to the dip of the fault plane it may be that they pass at slight depth from the fragmental Modelo into the more solid strata of the older formations north of the fault.

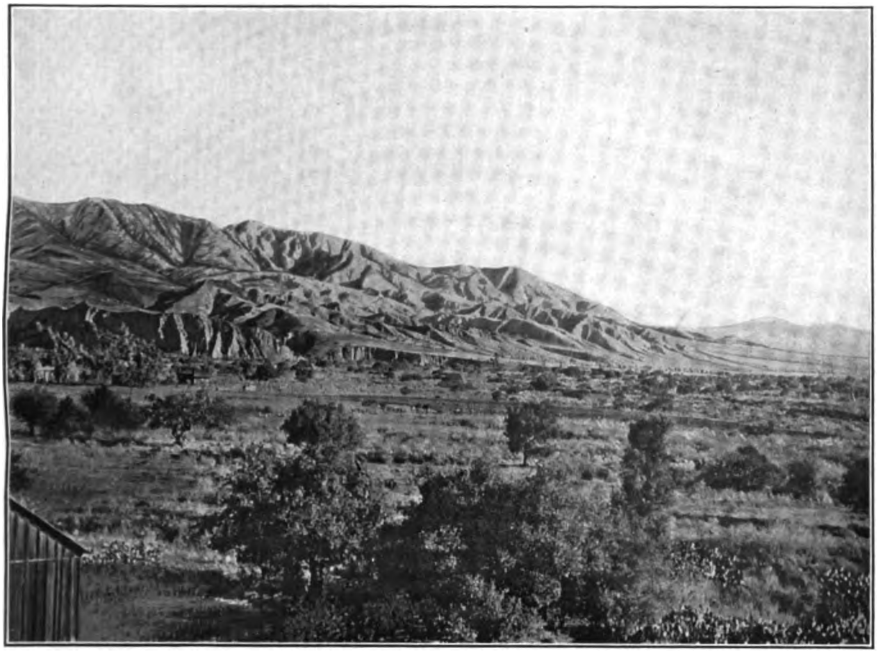
The maximum depth attained is a little over 1,000 feet. The wells are all small, 12 barrels per day being the largest individual yield at the present time. The gravity of the oil varies somewhat from well to well, but the average is approximately 19° B. The color of the oil is green. The only flowing wells are those of the Ojai Company, which lie west of the others, with their collars at a considerably lower elevation; they are also very shallow and are, moreover, located directly in the line of seepage of the region.



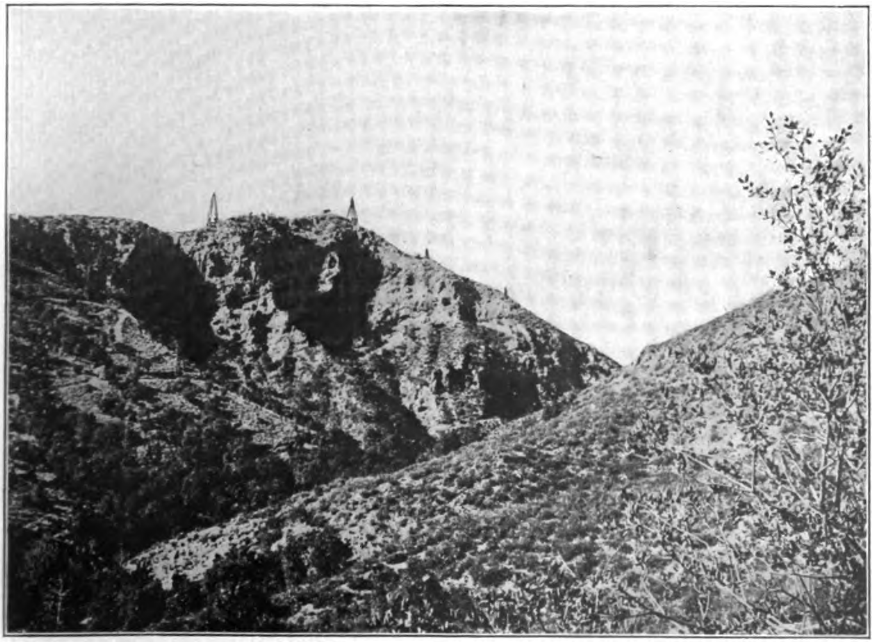
A. SANTA PAULA CANYON, FROM



B. ELSMERE RIDGE AND OIL WELLS, N



SANTA PAULA, VENTURA COUNTY.



AR NEWHALL, LOS ANGELES COUNTY.

FIELD SOUTH OF SANTA PAULA RIDGE.

LOCATION.

The productive oil territory immediately east of Santa Paula Canyon lies at the foot of the steep southern face of San Cayetano Mountain and is the eastward extension of the Ojai, Silver Thread, and Sulphur Mountain districts. The general configuration of the district is shown in Pl. VII, *A*, a panorama looking north from Santa Paula, in which this field appears along the face of San Cayetano Mountain on the right The sharply eroded ridges in the middle distance on the right are composed of the Fernando conglomerate, sandstone, and clay.

GEOLOGY AND STRUCTURE.

The great San Cayetano fault, along which the late Tertiaries are in contact with the Topatopa formation, lies at the base of the steeper portion of San Cayetano Mountain, at the upper edge of the lofty foot slopes, 2,000 feet above sea level. Along this line the oil-producing territory has been found, the area of yield widening somewhat with the appearance of other members of the fault system, in the direction of Santa Paula Creek. In this direction, too, the succession of strata and their relations become more and more complex.

The sediments involved in the productive region east of Santa Paula Creek include unmistakable Topatopa beds; a small wedge of the rusty Eocene sandstone, shale, and *Ostrea*-bearing limestone from the Silver Thread field; shale of the Modelo type, and a succession of sandstone, conglomerates, and blue, mud-like arenaceous clays, that have already been referred to as probably of Fernando (Pliocene) age. These last are the same as those occurring in Adams, Wheeler, and Aliso canyons and are also to be seen in strong outcrops crossing Santa Paula Creek from 3 miles above the town of Santa Paula to a point within a mile of Sisar Creek. The Modelo is identified by the siliceous character of its shales and by their organic life. As it is, however, in a locality in which the rocks are badly crushed and in which there is a rapid succession of interfault blocks, it is impossible to recognize its relations to adjacent beds.

A typical section (see Pl. III, sec. C–C′) of the field, directly across the strata from a point about 2 miles east of Santa Paula Creek, in the vicinity of the Hartford well, is as follows: On the north the typical Topatopa, succeeded across a fault plane by a siliceous shale typical of the Modelo. South of this is a large body of brown shale with limestone lenses, which under ordinary circumstances would be regarded as also a part of the Modelo, but which is less siliceous and more earthy than many of the Modelo beds. Still farther south are Fernando sandstone and conglomerate, which, with shale and clay, extend well out beneath the sloping foothills of the range. The strata in the fault zone and adjacent to it on the south have a northerly dip, varying from 80° in the sandstone and conglomerate just south of Bear Canyon and the well area to 50° in the well area itself and to 30° in the escarpment of Santa Paula Ridge and San Cayetano Mountain. The throw of the fault plane separating the Modelo and the Topatopa formations amounts, doubtless, to many thousand feet. A second fault probably exists in the interval between the Modelo siliceous shale and the Fernando sandstone and conglomerate south of Bear Canyon and at the head of Mud Gulch, the intervening brown shale, which is earthy and stained with bitumen, belonging, in the writer's belief, to the older formation. The strata south of the second fault are probably overturned, and only at a depth of 1,000 or 2,000 feet assume their regular dip to the south. This fault is probably the easterly extension of that existing along the southern base of Sulphur Mountain, since its trend and that of the adjacent strata is N. 65°-80° E., in conformity with the strikes in the latter region. The northern fault is doubtless the extension of the fault passing north of Sulphur Mountain, its trend and that of the lines of stratification adjacent being N. 65°-80° W. The extent of throw along the southern fault is undetermined and may vary from 500 to 1,500 feet. These two faults come together about 5 miles east of Santa Paula Creek, in the vicinity of the Empire wells, and east of this point only a single fracture is present.

OIL WELLS.

The wells of this field are confined chiefly to the brown shale and range in depth from a few hundred to nearly 2,000 feet. Sandy beds undoubtedly occur; but in the main the strata are blue, brown, and black shale, with occasional harder layers, known to the drillers as "hard shells." The oil is found in the coarser sediments. The Empire wells, in the eastern part of the field, show traces of the Fernando sandstone and conglomerate, from which, doubtless, they draw a portion of their oil, the remainder coming from the underlying Modelo formation. Some of the wells of this field are reported to have started at 200 barrels or more, the yield after a short time falling off until it is now between 5 and 20 barrels. The oil is light, its gravity being 35° B., and of greenish color, resembling in a measure that from the same formation in the Puente Hills.

The companies operating east of Santa Paula Creek are the O'Hara, the Chicago Crude, the Paxton Gold Bond, the Pure, the Hartford, the Cuniff, and the Empire.

SESPE FIELDS.

LOCATION.

The Sespe fields include that portion of the territory north of the Santa Clara Valley which lies adjacent to Sespe Creek in the lower 8 or 10 miles of its course, together with the area about Little Sespe, Fourfork, Tar, and Bear creeks and Pine and Coldwater canyons—all in the Sespe drainage system.

STRUCTURE.

In the Sespe district the formations begin to show crumpling, at first gentle, then severe, at the northern border of the Camulos quadrangle. The axis of the general fold lies just outside the quadrangle, while south of the fold is the edge of the broad table of Sespe red beds. (See Pl. III, sec. X-Z′.) In the country adjacent to the table of red beds on the south lies the axis of the Coldwater anticline, the lowest beds exposed being those at the base of the Sespe formation. The eastward extension of this anticline is somewhat uncertain, but it may prove to be continuous with or closely adjacent to the Ivers anticline, the axis of which is the seat of the Ivers oil wells. Both disappear in the folds at the gorge of Little Sespe Creek. South of the Coldwater anticline, confined to the narrow ridge between Coldwater and Pine canyons, is a sharply compressed syncline. This is nearly in line and may be continuous with the syncline that farther east passes through Oat Mountain and becomes one of the principal structural features of the region. In Pine Canyon, at the base of the ridge carrying the syncline above mentioned, the Topatopa formation reappears from beneath the Sespe beds and with northerly dip constitutes San Cayetano Mountain and Santa Paula Peak and the general mountain mass of which they are such conspicuous features. The structure of this mountain mass is monoclinal, developed, doubtless by faulting, from an overturned anticline whose arch could have been but little less than that of the main Topatopa fold farther north. The southern face of the monocline is a bold escarpment of 2,000 feet, in which the strata still show remnants of the arch. The displacement at this fault is probably 3,000 or 4,000 feet.

East of Sespe Creek the more important subordinate folds on the flanks of the main flexure include the Oat Mountain syncline, already referred to; an anticline that crosses lower Pole Canyon at the sharp turn from south to west; and another anticline, a mile farther south, that passes into the valley of Sespe Creek immediately below the entrance of Pole Canyon. Each of these folds is a conspicuous feature, but the syncline is perhaps the most marked, involving the strata from the Modelo to the red beds of the Sespe. In addition to these there are numerous local folds of but little less importance than those just mentioned. One or two of these local flexures are accompanied by faults, forming highly-crumpled zones.

The portion of Sespe Canyon lying above its confluence with Little Sespe Creek is the seat of marked disturbance. Apparently, there has been not only folding in conformity with the general east-west trend of the main anticline, but also a transverse buckling of the strata along strike lines that probably took place synchronously with the development of the principal folds. This buckling resulted in the sharp changes observed in the direction of structural lines and rendered still more complex the general folds and faults that affect the strata, especially in the angle between the main Sespe Creek and its tributary, Little Sespe Creek, and about the mouth of Sespe Canyon. In this region the regularity of the folds described in the preceding paragraphs has been almost completely destroyed, and the real structure is determined with difficulty.

The valley of Sespe Creek below the canyon is filled with Pleistocene deposits that conceal the older formations. East of the stream, in the lower slopes of Oat Mountain, there is a suggestion of the structure in the presence of *Ostrea*-bearing, rusty sandstone and shale, more or less calcareous, that closely resemble the rusty beds at the summit of the Sespe formation. These beds have a general N. 15° W. strike and an easterly dip. The strike becomes northwesterly toward the north, the beds evidently crossing the creek and uniting with those in the much-crumpled area immediately within the canyon mouth. To the south the rusty beds disappear beneath the overlying members of the Vaqueros formation, affording indications of a southerly dip beneath the valley. It is possible, however, that at this point there is a fault which has carried down the Modelo shale, bringing it into contact with the lower members of the Vaqueros formation and, perhaps, even with the rusty upper beds of the Sespe.

The strikes and dips here described suggest the east end of an anticline, most of which lies buried beneath the recent deposits of the Sespe and Santa Clara valleys. It is possible, too, that the trace of an anticlinal axis in the southern escarpment of San Cayetano Mountain, already referred to, may be a portion of the same flexure. In this case the San Cayetano fault may merge into this anticline on the east or it may die out in the much smaller fracture at the south end of Sespe Canyon, suggested in the preceding paragraph.

In the development of the earlier geologic features in the vicinity of the present Sespe Canyon there appears to have been formed, at the close of the Miocene, a structural bay, which was later filled with Pleistocene and, perhaps, Pliocene sediments. The uppermost Fernando or Pleistocene deposits are those which to-day are exposed in this locality. The lower Fernando is not exposed, but its outcrops cover considerable areas to the west and isolated areas also appear to the east, notably at the point of the foothills immediately east of Fillmore and in the vicinity of Piru. East of Piru the Fernando becomes the prevailing formation.

A stratigraphic feature that has considerable significance in connection with the geologic history of the Sespe region is the disappearance of the lower Modelo sandstone. In the area about the head of Hopper Canyon this terrane has an enormous development, its thickness amounting to at least 4,000 or 5,000 feet. Within the Sespe oil fields, however, its maximum is barely more than 1,000 feet and it disappears entirely in the slopes of Sespe Valley south of Oat Mountain. At other points within the confines of the oil fields it passes beneath the surface while still strongly developed, and its ultimate behavior is of course unknown.

The range south of Santa Clara River is seemingly a development independent of, though perhaps synchronous with, the mountains north of the river. There is, however, a degree of geologic relationship shown by the recurrence in the lower slopes of Oak Ridge of beds that from a paleontologic standpoint are undoubtedly the homologues of the lower portion of the lower Miocene which is encountered on Fourfork and Tar creeks. Below this paleontologic horizon in other portions of Oak Ridge, particularly to the west, still lower measures are exposed, consisting of brightly banded red and gray sandstone and sandy clay and heavier cross-bedded and somewhat conglomeratic rusty sandstone. This series is in general appearance very different from the Sespe beds north of the Santa Clara, yet in some of the details there is considerable resemblance. It would seem, therefore, that the horizons mentioned are repeated in the two localities, but with a certain differentiation of sediment and a reduced thickness to the south. Suggestions of such reduction are found even north of the Santa Clara in the westerly slope of Oat Mountain, where the Vaqueros and Modelo formations are perceptibly thinner than in their type localities.

The foregoing description of structure about Sespe Canyon is the result of a reconnaissance made with reference to the mode of occurrence of petroleum in the several localities in which it has been found. Detailed work, careful examination of individual strata for their fossil contents, and the tracing of the several horizons should lead to a much clearer understanding of the complexities that exist and might even alter the present exposition of some of the features. In the main, however, it is believed that the view presented is correct, and so far as it bears on the occurrence of petroleum it may be accepted.

OIL WELLS.

The wells in the Sespe district may be grouped as follows: Those of the Union Consolidated Oil Company in Sespe Canyon, at the base of Sulphur Peak; those in the vicinity of Devilsgate, a narrow gorge of the Sespe 2 or 3 miles below the Union wells; the Ivers wells, still lower in the canyon; the Kentuck wells, also in Sespe Canyon just above the mouth of Little Sespe Creek; the Happy Thought wells, on the south bank of Little Sespe Creek near its mouth; the Foot-of-the-Hill wells, on Little Sespe Creek a mile above its confluence with the main stream: the Fourfork wells, on an upper branch of Little Sespe Creek 2 or 3 miles above the Foot-of-the-Hill wells, and the wells on Tar Creek.

UNION CONSOLIDATED WELLS.

The territory being developed by the Union Consolidated Oil Company lies on the north flank of the main Topatopa anticline. At the time of the writer's visit the company had but a single productive well, located at the sharp bend of Sespe Creek opposite a minor tributary descending from Sulphur Peak and entering the main stream a mile above the mouth of Tar Creek. The purpose of this well was to tap the white sandstone at the base of the Sespe formation, a sandstone that here gives forth a considerable seepage of oil. The gravity of the oil of this well is about 11° B. A second well was about to be drilled by the same company half a mile farther up the canyon, starting in the upper part of the Topatopa formation. It is probable that the intention was to obtain a yield from some of the petroliferous sandstones in the upper part of the Topatopa, seepages from which occur in the river bed a few hundred yards above the location of the well.

REGION OF DEVILSGATE.

The oil wells in the vicinity of Devilsgate are located a short distance above the narrows of the Sespe gorge, close to the axis of the Coldwater anticline. The major part of this anticline lies west of Sespe Creek, the strata in the arch of the fold having been sufficiently crushed to determine the position of Coldwater Canyon. The general trend of the axis is N. 70° E., with an easterly pitch in the vicinity of Sespe Creek. About the end of this anticline the wells of the Russell Company have been drilled. The western limit of the anticline is not known, but it extends well toward the summit of the divide between the Sespe and Santa Paula drainage systems, and may perhaps continue into the upper canyons of the east fork of the Santa Paula. The territory that has been proved to be productive along this fold is at present confined to its most accessible point, Sespe Canyon. The possibilities for the remaining length of the anticline are yet to be determined.

The heart of the Coldwater anticline is occupied by the lower division of variegated strata at the base of the Sespe formation. The arch is well exposed in the canyon walls east of the Sespe channel, where practically the same succession of beds is to be seen as in the region of the Union Consolidated Oil Company's wells 2 or 3 miles farther up the canyon, at the base of Sulphur Peak. The lower members of the formation, however, are not exposed. The arch is comparatively symmetrical, and the wells lie on both sides of the axis and also of Sespe Creek. They penetrate strata lying below the division of greenish-gray shale in the upper part of this member of the Sespe, and it is reported that oil is derived from the white sandstone at the base of the formation, and possibly also from certain strata in the upper part of the Topatopa formation. The source of the oil is, therefore, supposedly the same as in the wells of the Union Consolidated Oil Company. The wells, five in number, yield a black oil of heavy gravity. One of the wells is said to have produced 40 barrels of heavy oil per day and to have yielded enough gas to run a 30-horsepower boiler. Considerable water rises with the oil, but of course is easily separated in the settling tanks. No shipments of oil have as yet been made from this field, the entire product being consumed in the operations of drilling.

IVERS WELLS.

The Ivers wells, located in Sespe Canyon a short distance below Devilsgate, are drilled on and near the axis of a local anticline in the red sandstone lying about midway of the Sespe formation (see fig. 5).

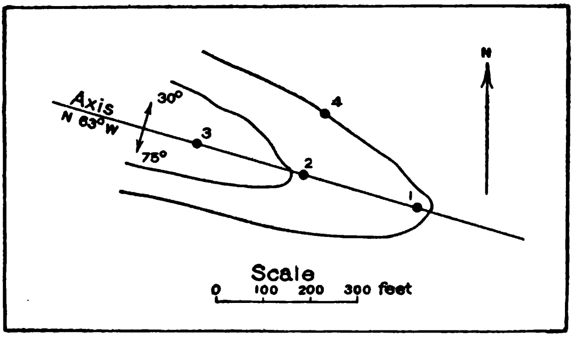


FIG. 5.—Sketch map showing location of Ivers wells with relation to anticlinal axis in the Sespe red beds. Heavy dots, wells productive in 1902. Figures indicate numbers of wells. Lines show outcrop of beds around nose of anticline.

The anticline has a trend of N. 65° W. with an easterly pitch. A transverse section of the anticline indicates a dip of about 75° on the south limb and 30° on the north limb. The particular horizon affording oil is possibly well toward the bottom of the red beds, and is at least 600 feet lower than that from which the oil of the Kentuck wells, one-half or three-fourths of a mile to the south, is derived.

The westward extent of the Ivers anticline was not determined, nor are its relations to the other folds of the region known. Its general trend would carry it toward the mouth of Coldwater Canyon. The change in direction exhibited by the numerous folds in this region suggests that the Ivers anticline may be continuous with the Coldwater anticline, the main curvature taking place at some point between the two groups of wells, probably on the slope toward Coldwater Canyon. On the other hand, the Ivers anticline may be merely a local crumple, one of the many that were evidently formed in this region.

The Ivers wells are four in number, the oldest having been drilled about fifteen years. The early production of this well is said to have been about 20 barrels per day, but the four wells together at the time of the writer's visit were not producing over 11 barrels. It may be added, however, that the condition of the wells was not conducive to their maximum possibilities, for they are cleaned only at long intervals. The oil is black and is said to vary slightly in gravity from well to well, the average being about 17° B. The depth of the wells is reported as between 800 and 1,000 feet.

Incidentally it was learned that the cost of production for the four wells in 1902 was only about $3 per day, including $2.50 wages paid a pumper. Eleven barrels of oil per day at 50 cents yielded $5.50, indicating a profit of $2.50 per day, or about $75 per month.

Concerning the extension of the productive area westward along this fold there is, of course, a question. Seepages, however, are reported for its entire length, or well down the slope on the east side of Sespe Canyon above Devilsgate.

KENTUCK WELLS.

The Kentuck wells, in Sespe Canyon, just above the mouth of Little Sespe Creek, are unique from the standpoint of their structural location, for they lie along or in proximity to the axis of a syncline, which is, moreover, one of the most prominent in the fields north of Santa Clara River. It must be said, however, that the region is one of exceedingly sharp compression, and it may be due to this that local channels and reservoirs conducive to the accumulation of oil have been formed under what might ordinarily be construed as unfavorable structural conditions. Throughout the Coast Range are many instances of oil having been obtained from wells drilled in highly crumpled strata.

The syncline in which the Kentuck wells are located is traceable eastward through the summit of Oat Mountain and across Pole Canyon to Hopper Canyon, where it perhaps unites with another syncline of northeasterly trend, the curvature marking the change in direction which is characteristic of all the successive folds encountered from north to south along this gorge. To the west evidences of the syncline are to be found almost to Devilsgate, and it is possible that in this direction the fold is continuous, though in a curved line, with that occupying the ridge between Coldwater and Pine canyons. The pitch of the axis of this syncline is toward the east, the strata becoming successively higher as distance in this direction is gained. This fold is the most prominent lying between the main Topatopa anticline and the series of folds which pass across the outer hills of this mountain mass.

On account of the unusual structural position of the Kentuck wells a sketch of their location with reference to the axis of the syncline is given in fig. 6. Although they are identified with the synclinal structure it might be said that those on either side of the axis are on the corresponding slope of the adjacent anticline, and perhaps this is the true way in which to regard them. Although the syncline is a prominent fold, it is, nevertheless, like the adjacent Ivers, Coldwater, and other anticlines, subordinate to the great anticline of the Topatopa Range, and the effect of the local structure may be lost in the general position which it occupies on the flanks of the far broader fold. It seems to the writer to be only in some such way as this that the presence of oil here and elsewhere along the axes of minor folds and even faults in this region can be accounted for. Incidentally, it is worthy of note that along portions of its length this syncline, as well as the adjacent folds, is so compressed that the plane of its axis is thrown past the vertical, the strata on both sides dipping to the north. In the immediate vicinity of the Kentuck wells, however, this overthrow has not taken place.

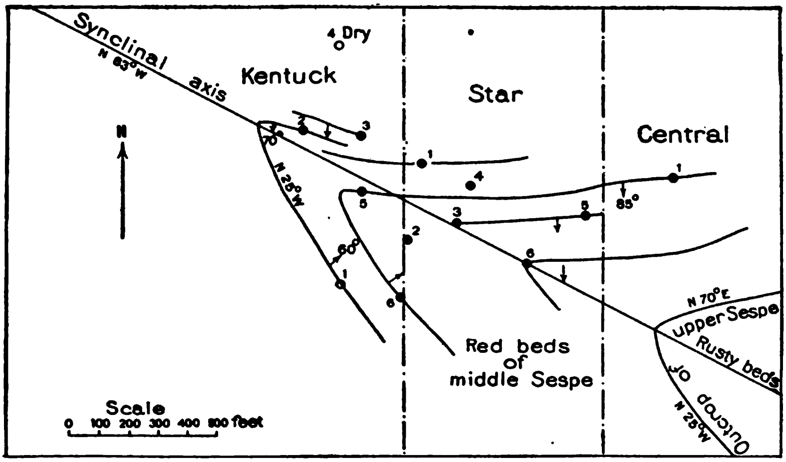


FIG. 6.—Sketch map showing location of Kentuck group of wells in syncline in Sespe red beds. Heavy dots, productive wells; circles, dry wells. Lines indicate outcrops around syncline. Figures refer to numbers of wells or to dip of strata.

The horizons from which the Kentuck wells draw their oil are about midway of the Sespe formation. The logs of the wells show that the strata penetrated are sandstone, with minor layers of shale, all of a reddish color. The depth of the wells varies from 600 or 700 feet to nearly 1,500 feet, and they pass through several zones that furnish oil in commercial amounts. The more productive body of rock, however, is encountered in the lower half of the drill holes. The oil is of a dark green to black color, and its gravity is said to be about 30° B. In January, 1906, only seven wells of this group were pumping, four on the Kentuck property and three on the Star. No. 4 Star was abandoned, because of the oil giving out and water coming in.

HAPPY THOUGHT WELLS.

The Happy Thought Oil Company's wells are located in the SE. ¼ sec. 1, T. 4 N., R. 20 W., on the south side of Little Sespe Creek, immediately east of its confluence with the main stream. The wells are drilled in the steeply dipping beds on the south side of the syncline from which the Kentuck wells derive their oil. In the Happy Thought territory, however, this syncline plunges rapidly toward the southeast, so that, considered from one point of view, the wells penetrate strata dipping southeastward from a hypothetical anticlinal axis somewhere to the northwest, possibly the Topatopa axis. The wells start just below the brown sandstone at the top of the Sespe red beds, the oil, it is said, being derived from several layers of soft sandy shale between harder impervious beds. On account of the steep dip of the rocks and their alternating hard and soft composition, drilling on this property is reported to be difficult.

The company now has three wells down and is drilling a fourth. The wells are less than 1,000 feet in depth, the oil being encountered at about 500 feet. The production is good at the start, and although falling off after a while, soon reaches a normal rate that is about the average of the other wells in this region. The oil is brown and the gravity about 27° B. A 2-inch pipe line connects the Happy Thought property with storage tanks at Brownstone, 3½ miles distant, whence the oil is shipped by rail to San Francisco.

FOOT-OF-THE-HILL OR LOS ANGELES WELLS.

The Foot-of-the-Hill or Los Angeles wells, eight in number, are located on Little Sespe Creek about a mile above its entrance into the main stream. They are the westernmost wells in the southward sweep of the strata after their passage around the broad east end of the general Topatopa anticline. They are also adjacent to, yet in strata not involved in, the zone of highly crushed rocks that form so conspicuous a feature at the confluence of Little Sespe and

Sespe creeks. They are, therefore, to be compared with the Fourfork and Tar Creek wells rather than with the Kentuck, Ivers, and other wells farther west. Drilling was started in the upper, rusty division of the Sespe formation, but the source of the oil is either in the lowermost strata of this division or in the uppermost of the red beds. The wells are from 800 to 1,600 feet in depth, and their oil-bearing zones constitute the fourth general horizon at which oil has been found in the Sespe formation. Their source of supply is below that of the Fourfork wells, which is, therefore, a fifth horizon in this great series of red beds and their associated strata.

While the foregoing statement doubtless covers the general conditions of the occurrence of oil in this vicinity, the fact that the wells are in line with a minor anticlinal flexure which appears in the summit of the ridge to the east must be kept in mind. It is to be observed also that their position is at a point where the strike of the beds changes rather abruptly from northerly to westerly; they are also in one of the inner concentric belts of strata which are involved in the general Topatopa anticline; thus it may be that the conditions are almost analogous to those of an anticline. In conditions somewhat similar to this many productive wells of the Coast Range fields have been found. Fig. 7 is illustrative of these conditions. The relative positions of the wells are closely approximated, although the results are not those of an actual survey.

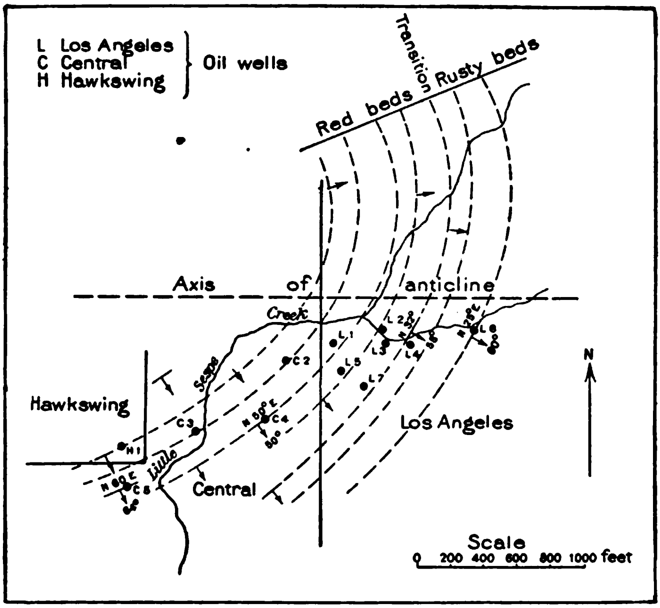


FIG. 7.—Sketch map of Foot-of-the-Hill oil wells, showing location with relation to Little Sespe Creek and the geologic formations. Heavy dots, wells productive in 1902. Broken lines indicate outcrops around nose of anticline. Figures are numbers of wells or dip of strata.

At the time of the writer's visit to the locality in 1902 it was impossible to learn the precise depth of the several wells or whether the source of the oil was the same in all. The position of certain wells on strata following the inner curve, and of others on higher strata following an outer curve, taken in conjunction with the actual difference in elevation of about 300 feet, would indicate that possibly the oil zone is of considerable breadth and thickness.

FOURFORK WELLS.

The Fourfork wells, 15 in number, are located along one of the main branches of Fourfork Creek, a tributary of Little Sespe Creek.

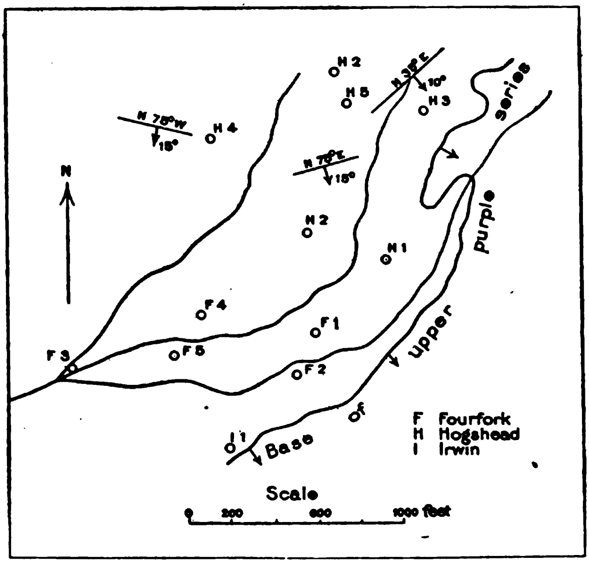


FIG. 8.—Sketch map showing location of the Fourfork group of wells on Fourfork Creek with relation to the base of the upper purple beds. Circles, wells productive in 1902. Figures indicate numbers of wells or dip of strata.

They are but a little west of the divide between this stream and Tar Creek. The altitude of their collars varies from about 2,200 to 2,700 feet above sea level. Their depth is between 1,200 and 1,800 feet, in rocks which strike in general about N. 50° E. and dip 35°–45° SE. The strike is, however, but a part of the broad curve which is assumed by the strata in their passage about the east end of the Topatopa anticline. Stratigraphy and structure are both regular in the vicinity of the wells, a complete absence of the minor flexures which form so common a feature in other portions of the adjacent mountains being noteworthy. It will be recalled that the succession of strata in this vicinity, from the base upward, is the red beds and rusty beds, both regarded as Sespe; the purple shale, gray shale, and upper purple or maroon measures (Vaqueros); the siliceous shale (Modelo), and the Modelo sandstone. The wells penetrate the lower third of the series, starting at horizons in or near the top of the lower purple shale and reaching perhaps the lower part of the rusty, calcareous sandstone which constitutes the upper division of the Sespe formation. It may be even that the upper part of the red beds is reached, red sand having been encountered in the bottom of some of the holes. Fig. 8 indicates the general disposition of these wells. Their production has been comparatively large, 200 barrels a day being the record of several at the start. Within a year, however, most of them decreased to about 60 barrels, and at the present time few yield more than 20 to 30 barrels a day and many much less. The gravity of the oil is about 32° B.—the same as that of the Tar Creek wells.

The feature of especial interest in regard to the Fourfork wells is their altitude, coupled with the fact that they derive their oil from the same general zone, although from a somewhat different horizon, as the Tar Creek wells to the east and those of the Foot-of-the-Hill district to the west. This indicates an undulation of the oil table or the altitude at which the oil stands in the same bed.

TAR CREEK WELLS.

The Tar Creek wells are located in the southwestern portion of the Tar Creek amphitheater, which is drained by several tributaries flowing directly into this stream, including one of its principal branches known as Bear Creek. The wells number between 20 and 30, but are now mostly abandoned, their yield having fallen to but 3 or 4 barrels a day. Originally 100 to 200 barrels was the production. Like the wells of the Fourfork region, these also are distributed along the curve of the strata as they bend about the axis of the Topatopa anticline. The local strike varies, however,, slightly on either side of N. 10° E., and the dip is generally between 25° and 30° SE. The strata penetrated are apparently somewhat higher than those of the Fourfork region, and these are, therefore, the highest wells thus far considered in the Sespe region. One at least starts near the top of the gray shale about midway of the Vaqueros formation; the others start somewhat lower; a few wells, the shallowest of the group, start at a comparatively short distance above the rusty beds of the upper division of the Sespe formation. Oil appears to be obtained at depths between 230 and 1,700 feet below the surface, in the lower portion of the Vaqueros formation or the rusty beds in the upper portion of the Sespe. There is evidence, however, that many oil-bearing horizons were passed in the younger beds overlying these members. The presence of oil in these younger beds is undoubtedly due to the occurrence of fine sands or other porous materials, which are distributed through the series and which form the reservoirs for the collection of oil from the more shaly members. The logs of some of the wells indicate that a considerable amount of sand had been penetrated by the drill, but it is probable that the strata are sandy shale of fine grain rather than distinct sandstone. Occasionally red sand has been reported from some of the wells at depths less than 1,000 feet, but it is probable that this is the purple or reddish shale constituting the lower part of the Vaqueros formation.

In the field it was thought that a slight local undulation of the beds could be detected in their broad sweep about the axis of the general Topatopa anticline. A like occurrence was suspected in the Fourfork district. Slight as these are, they should not be disregarded in an attempt to collect facts bearing on the conditions under which the oil of the Coast Range is found.

The yield of these wells is very irregular and the accumulation of oil is readily pumped off. It is reported by the man in charge of the wells that they are affected by rain, the yield increasing materially after a heavy fall.

POLE CANYON.

LOCATION.

Pole Canyon, although but 2 miles from Sespe Creek, lies wholly beyond the area of disturbed rocks that are so well developed at the entrance to the gorge of the Sespe. Although no productive wells have yet been drilled in this territory it is deemed advisable to include here a short discussion of its structure, as it connects two productive areas and may at some future time be found on careful prospecting to be itself an oil-producing region.

GEOLOGY AND STRUCTURE.

Pl. II, sec. F–F′, is illustrative of the conditions along the lines F–F′ of the general map (Pl. I) which are practically those prevailing along Pole Canyon. At the north end of the section, on the eastern flank of Hopper Mountain, the southern and western edge of an extensive outcrop of Modelo sandstone is seen. South of this outcrop is a narrow belt of Vaqueros shale which is locally crumpled into an asymmetric anticline. South of the Vaqueros area the Modelo formation reappears, turned past the vertical at the crest of the ridge east of Pole Canyon, but quickly regaining its southerly dip in the slopes below. At the lower edge of the outcrop there is some confusion in the succession of strata and in the dips and it is believed that a slight displacement has taken place in addition to an overthrow. The overthrow is best observed in the upper Modelo sandstone, which outcrops in a continuous half circle, the axis of the fold pitching about 45° SE. In this sandstone also is well shown the principal syncline of the region, which may be designated the Oat Mountain syncline, its western extremity lying in that mountain. Except for sharp anticlinal crumples near its northern and southern edges, this syncline is comparatively symmetrical, the outcropping stratum in the trough of the fold being the uppermost shale of the Modelo formation. Immediately south of the southern anticlinal crumple is a second fault, designated the Sulphur Mountain fault, its trend being N. 60° W., the direction of its hade doubtful, though perhaps to the south, the downthrow to the south, and the maximum displacement probably more than 1,000 feet. This fracture is traceable diagonally across Sulphur Mountain to the bottom of the Santa Clara Valley; it is also in direct line with certain sharp crumples in Chaffee Canyon, south of the valley, to which, therefore, it may be structurally related. To the west the fault passes into the ridge running south from Oat Mountain, perhaps continuing to Sespe Canyon and merging with the San Cayetano fracture. Over this portion of its course, however, its identification is next to impossible, for the strata are but a succession of shales which may be either Vaqueros, Modelo, or both. These shales are of great thickness and extend southward in unbroken outcrop to the Santa Clara Valley, only a narrow fringe of overlying Pliocene separating them from the bottom lands for a mile or two along their front. The shales display a number of minor folds, but their predominant dip is northward. Just before passing beneath the Pliocene, however, this seems to change to southward, more or less in conformity with that of the younger rocks. Across the Santa Clara Valley, but at a distance of nearly 2 miles, the probable upper members of the Sespe and lower members of the Vaqueros appear, but the intervening structure is unknown.

In a broad way the folds along the section just described appear to divide themselves into three major and half a dozen or more minor folds. The major folds include the anticlines at the north and south ends of the section and the intervening syncline; the minor folds the crumples on the sides of the syncline. Of the major folds the syncline extends farthest toward the area of confused structure at the mouth of Sespe Canyon, perhaps being involved in it; the northern anticline apparently disappears on the southeasterly slope of the general Topatopa fold; while the anticline at the south is lost beneath the recent deposits of the Sespe and Santa Clara valleys.

East of the line of the section both major and minor folds in the main continue to the center of curvature a mile west of Hopper Canyon, where the strata bend from a northwesterly to a northeasterly trend. Indeed, the folds seem in places to bend in like manner or at least to pass into others of northeasterly trend, similarly developed farther east.

HOPPER-PIRU FIELDS.

LOCATION.

The district discussed in this section embraces the territory contiguous to Hopper and Nigger canyons, the lower portion of Piru Creek, and its tributaries Modelo, Blanchard, Lime, and Reasoner canyons on the west and Santa Felicia and Holser canyons on the east. The topography, especially about Hopper Canyon, is very rugged, but considerable portions of the district are accessible over the roads which follow the canyons. Piru, at the mouth of Piru Creek, is the only town of importance in the district.

STRUCTURE.

WEST OF PIRU CREEK.

Within the drainage area of Hopper Canyon the structure varies so abruptly that to indicate it completely would require cross sections every quarter or half mile; a general idea of it may, however, be gained by the examination of sec. G–G′, Pl. IV, which represents a north-south section through Piru Peak.

The Hopper Canyon section proper reveals at its north end a short, though pronounced anticline of northeasterly trend, with a narrow core of Vaqueros beds exposed at its center and the Modelo sandstone arching over and about its end a short distance to the east. In the Piru Peak section this anticline is probably represented by the slight pucker near the north end. Near the middle of the section is the sharply compressed Modelo anticline, showing in massive beds of the lower Modelo sandstone. Between this anticline and that first mentioned are several sharp puckers, the most pronounced being that on the syncline which passes south of Piru Peak. For this portion of the section the thickness of the Modelo sandstone is estimated at about 3,000 feet.

The Modelo anticline is one of the most conspicuous of the secondary folds in the field. The arch shows to best advantage at the head of Modelo Canyon, where the lower Modelo sandstone on either side is sharply compressed. The dips are between 60° and 80°, but the southern limb of the fold is perhaps a little steeper than the northern limb. The anticline may be traced westward to Hopper Canyon, beyond which it either disappears or merges with one or another of the folds that occur in the Vaqueros shale. Eastward the fold is traceable to Piru Creek, where it seems to disappear, unless it should by a sharp curve merge with the Holser anticline, half a mile to the south. In the lower portion of Modelo Canyon the upper sandstone of the formation, together with the underlying shale, shows marked crumpling, the crest of the fold being carried past the vertical. The succession of strata on the two sides of this fold does not appear to be exactly the same, the relative proportion of sandstone and shale being somewhat at variance. This probably is due to concealed faults a short distance south of the axis.

The Modelo anticline is the seat of two important fields of oil. One is developed close to and on either side of the axis of the fold, along the upper course of Modelo Canyon and at the divide between this canyon and the drainage flowing to the west; the other is developed by the Sunset wells near stream level in Hopper Canyon. Other portions of the anticline are as yet undeveloped, but there is no evidence to show that such areas do not contain oil, and it seems probable that search by the drill would be rewarded.

South of the Modelo anticline are two successive synclines separated by a fault. These appear both on the general section (Pl. III) and on sec. G–G′ (Pl. IV). The rocks involved are the lower and upper Modelo sandstones and the intermediate and overlying shales. The evidence of the fault lies in the irregularity of outcrop at the head of the south fork of Modelo Canyon, in the succession of strata in Lyons Peak and farther west, and in the fractured condition of the beds overlooking Hopper Canyon. As exposed at the surface, the fault seems to be confined to the shale between the two Modelo sandstones. It is difficult to estimate the amount of throw that may have taken place, but it is at least 500 feet at the point of maximum development and perhaps much greater. To the east the fractured condition of the rocks continues for at least half the length of Modelo Canyon but here possibly the fault dies out on the southern limb of an exceedingly sharp fold that appears in a prominent knoll just north of the gorge, directly in line with the axis of the Modelo anticline. The effects of the fold doubtless extend as far east as Piru Creek, possibly beyond. The western terminus of the fault is uncertain. South of the fault the upper Modelo sandstone appears to have been folded into a sharp syncline.

Less than half a mile south of the syncline just mentioned lies the Lyons anticline, which is the third important anticline of the region and which crosses the lower portion of Nigger Canyon. The arch is well shown in the divide immediately east of the Lyons wells in the upper Modelo sandstone and the shales immediately above and below. The shale is more conspicuous in the heart of the anticline to the west, while the sandstone may be seen on the slopes toward Piru Valley, curving about the underlying bed. The trend of this anticline is approximately N. 80° E. from Nigger Canyon eastward and S. 65° W. from half a mile west of Nigger Canyon westward. This curve conforms to that of the other folds both to the north and to the south. To the east the Lyons anticline was not recognized with certainty beyond Piru Creek. Its trend is toward the Holser anticline, south of the Holser Canyon, but whether the Lyons or the Modelo anticline is continuous with the Holser is undetermined. In general, there is great confusion of strikes and dips in the slopes of the hills west of Piru Creek for the lower 2 or 3 miles of the valley, and without further details it is impossible to affirm whether or not any of the folds are continuous with other folds that appear to the east of the stream. In the Hopper Canyon section the Lyons anticline shows conspicuously in the middle Modelo shale. It is probable also that a fault has developed along the axis of the fold in this locality, the beds to the south having been carried downward several hundred feet. The maximum displacement appears to be along the east-west lateral entering Hopper Canyon from the east half a mile above its mouth. The fracture seems to have resulted from the excessive local development of the anticline into an overturned or reversed fold. The attendant displacement accounts for the discrepancy in the distances of the Modelo sandstone from the apparent axis of the fold on one side and the other, in the line of the Hopper Canyon section. West of Hopper Canyon the fault is marked by a zone of highly contorted and fractured strata, having a width of about 400 feet. The direction assumed by the fault would carry it directly against the Sulphur Mountain fracture a mile farther west at an angle of 60°.

A short distance south of the Lyons anticline the Modelo formation is unconformably succeeded by heavy conglomerates and sandstones of the Fernando formation. Near the contact east of Hopper Canyon the dip of the younger strata is southward. East of Nigger Canyon, however, the Fernando beds are overturned, with a steep northerly dip, but this probably changes to southerly as the beds pass beneath the Santa Clara Valley. From this point the line of unconformity between the Fernando and Modelo formations passes, with a curvilinear trend, northward above the mouth of Holser Canyon, remaining east of Piru Creek.

At the line of the general section (Z–Z′, Pl. III) the Fernando formation is narrow of outcrop and highly inclined, but otherwise simple of structure. A short distance to the east, however, it is folded, and the folds become more pronounced and extensive across Piru Creek, developing into an anticline of considerable proportions, with several minor crumples near by on either side.

The Fernando and underlying beds pass beneath the Santa Clara Valley, but although the distance across the valley is less than 2 miles the Modelo formation has apparently disappeared on the south side, the principal formation in the hills being the Vaqueros, with Fernando rocks here and there resting against it above the valley level. This occurrence suggests possible faulting along the valley, with overlap of the Fernando on the older Miocene beds.

The fold next north of the Modelo anticline is the syncline that passes south of Piru Peak. It may be seen both on the west side of the divide and east of the peak in the upper portions of Blanchard Canyon. The crumpling is slight and the dip on either side of the axis comparatively gentle.

North of this syncline is another anticline of importance, the axis of which passes east and west across Lime Canyon. The heart of this fold is occupied by the lower Modelo sandstone, which is here exposed over an area of 3 or 4 square miles. It is surrounded by the overlying shale, which in the divide north from Piru Peak forms scarcely more than a thin film. To the east across Piru Creek the shale is succeeded by the upper Modelo sandstone, and this in turn by the still higher siliceous shale at the top of the Modelo; finally the heavy mass of the Fernando sediments sets in, arching about and over the eastward-pitching axis of the fold.

The northernmost fold along this section within the Camulos quadrangle, with the exception of one or two minor crumples, is the Reasoner syncline, the axis of which occupies Reasoner Canyon. This flexure disappears, however, in the divide at the head of the creek, where the heavy lower Modelo sandstone lies in a broad arch about the axis of the Topatopa anticline. To the east the syncline continues for an undetermined distance beyond Piru Creek, being conspicuous in the Fernando conglomerate and sandstone in the hills between Santa Felicia and Devil canyons. Both slopes of the syncline are gentle, the dip generally being less than 40°; but there are areas in which this is somewhat increased by local crumpling.

The northernmost of the folds described in the preceding paragraphs and others beyond the confines of the Camulos quadrangle all fade into or are developed as minor crumples on the general easterly slope of the main Topatopa anticline.

Within the region here described the three prominent anticlines, the Hopper, the Modelo, and the Lyons, have proved oil bearing, the Modelo being the most productive, perhaps on account of its greatest development; the Lyons less so, and the Hopper the least. On the Hopper fold, however, there is at the present time but a single well of low yield.

STRUCTURE EAST OF PIRU CREEK.

The region east of Piru Creek presents a number of approximately east-west folds, some of which, particularly the more northerly, are continuations of those lying west of the stream already described, while others farther south are apparently restricted almost wholly to the area east of Piru Creek, only their extreme points extending westward across the stream. Of the latter, the Holser anticline is the most conspicuous. The axis of this fold lies in the hills a little south of

Holser Canyon. Its trend is slightly north of west. It extends westward across the Piru Valley, perhaps connecting with the Modelo or the Lyons anticline, or with both. To the east it was recognized in the high knoll near the Ventura-Los Angeles county line, beyond which observations in detail were not carried. The surficial formation affected by this anticline is the Fernando, consisting of conglomerate, sandstone, and clay. Along its axis the coarser strata have at various places been impregnated with petroleum, and near one of these, in Ramona Canyon, the Ramona Oil Company is drilling a well, the depth at the time of the writer's visit being about 1,000 feet, but only the slightest traces of oil have been found. North of Holser Canyon is an abandoned dry well, known as the Crown King.

Between the Holser and Lime Canyon anticlines there is undoubtedly a syncline, but the details were not worked out for the region east of Piru Creek. To the south the Holser anticline occupies the space quite to the Santa Clara Valley, but on this limb of the fold (see Pl. IV, sec. I–I′), on the southern face of the outer ridge, a short distance below its crest, is developed a sharp pucker, by which the beds in the lower half of the ridge are turned past the vertical, having a northerly dip.

OIL WELLS.

The oil wells of the Hopper-Piru district comprise the San Cayetano, Sunset, Fortuna, Nigger Canyon, Modelo Canyon, Piru Oil and Land Company, and Holser Canyon wells. All but the last two groups are situated west of Piru Creek.

SAN CAYETANO WELLS.

The San Cayetano wells, three in number, lie near the forks of Hopper Canyon about 3½ miles in a direct line above its mouth and constitute the uppermost development in this gorge. They are drilled in the upper portion of the Vaqueros shale, the northernmost well starting but a short distance below the lower Modelo sandstone. The maximum depth is 600 feet. In one or another of them, however, oil has been found almost from the grass roots down in streaks of sandstone of variable thickness that are interbedded in the shale. With the oil has been found considerable water and gas. These wells lie in a region of great disturbance, which is attributable, perhaps, to the proximity of an anticlinal axis, in the first place, and to a sharp bend in the strata from a northwesterly to a northeasterly direction in the second place. This latter feature is repeated at the Sunset and Fortuna wells farther down the canyon. It may be reasonable to infer that while each of these three oil-bearing localities is that of an anticline, the curvature of the strata as a feature in the great Topatopa system of folds may also have acted favorably on the yield of petroleum in this region, the center of curvature in this case being construed as a part of the axis of an anticline. Such an occurrence has been encountered at a number of points in the oil fields of the Coast Range.

The anticline on which the San Cayetano wells are located has a northeasterly trend from a point a little southwest of the wells to the divide between Hopper and Reasoner canyons. The length of the fold is, therefore, about 2 miles. Except for these wells the anticline is unprospected, but there is no reason for the choice of one location over another. As the territory develops it will be interesting to note the success of drilling to the northeast of the present field. That the anticlines of this region may yield oil in more than one locality is evidenced by the Modelo anticline, which carries the very productive territory of the Modelo wells and also that of the Sunset Oil Company.

The yield of the San Cayetano wells is but 4 or 5 barrels of 14° gravity oil, but it is thought that this will increase as drilling is carried deeper.

SUNSET WELLS.

The Sunset wells, 11 in all, are located on the east side of Hopper Canyon, a short distance above the entrance of a lateral gorge that heads against Modelo Canyon. They penetrate the Modelo sandstone, which occurs also in the wells of the Modelo Oil Company to the east. The dip of the beds is about 45° N.—that is, the wells have been drilled on the northern flank of an anticline the axis of which has a general N. 80° W. strike. Apparently the anticline is the same as the Modelo, although the connection between the two has not been traced. The area covered by the Sunset wells is somewhat less than a half mile east and west by 500 to 600 feet north and south.

The depth of the wells is generally less than 600 feet. The production is between 3 and 15 barrels per day, with a variable and in several wells excessive amount of water. It is thought that the production might be considerably increased by cleaning the wells. The oil is run into a common tank, and the gravity there obtained by the writer was 16.4° B. An initial yield as great as 75 barrels was obtained from certain of the wells several years ago. In January, 1906, only five of the wells were being pumped.

The Sunset wells afford another case of production in a region of highly crumpled strata and a rapid succession of flexures.

FORTUNA WELLS.

The wells of the Buckhorn Oil and Transportation Company are, perhaps, best designated by their early name, Fortuna. The territory is the farthest south of the productive areas in Hopper Canyon, lying about 2 miles north of the town of Buckhorn.

This also is a group of wells that has been developed along the axis of one of the minor anticlines. (See Pl. VIII, *B.*) The fold has an apparent length of barely 1 mile, and it is in the midst of a series of closely spaced flexures. The strike of the anticlinal axis is N. 50° E., and the wells are distributed along the axis in almost a direct line. Fourteen holes have been drilled to a maximum depth of about 1,000 feet. The rocks penetrated are the siliceous and earthy shales that lie between the lower and upper Modelo sandstones. In one or two instances, however, the lower portion of the upper sandstone, which consists of alternating thin sandstone and shale beds, has been perforated. This horizon is the highest that is productive in the Hopper Canyon district. The Sunset wells draw from strata near the base of the Modelo formation, while the San Cayetano wells receive their supply from the upper members of the Vaqueros formation, which in turn are higher than any of the productive horizons in the Tar Creek and other districts already considered.

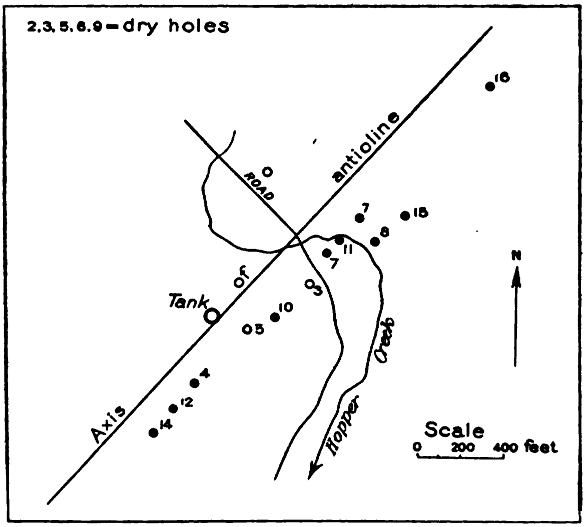
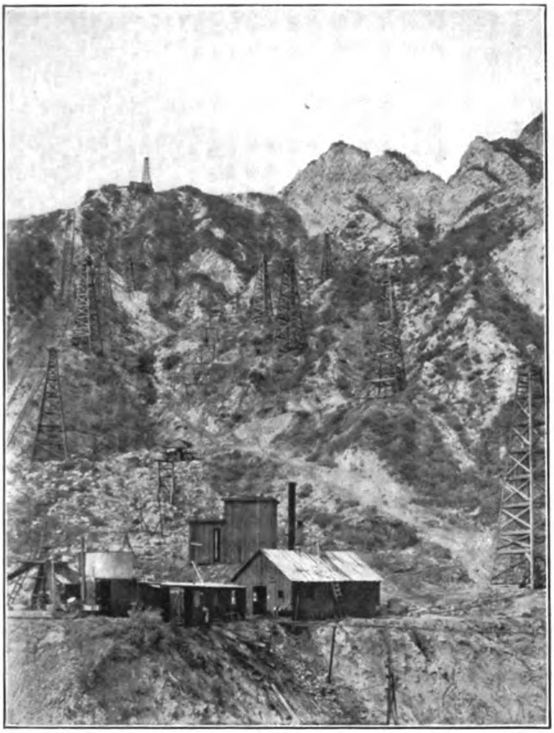


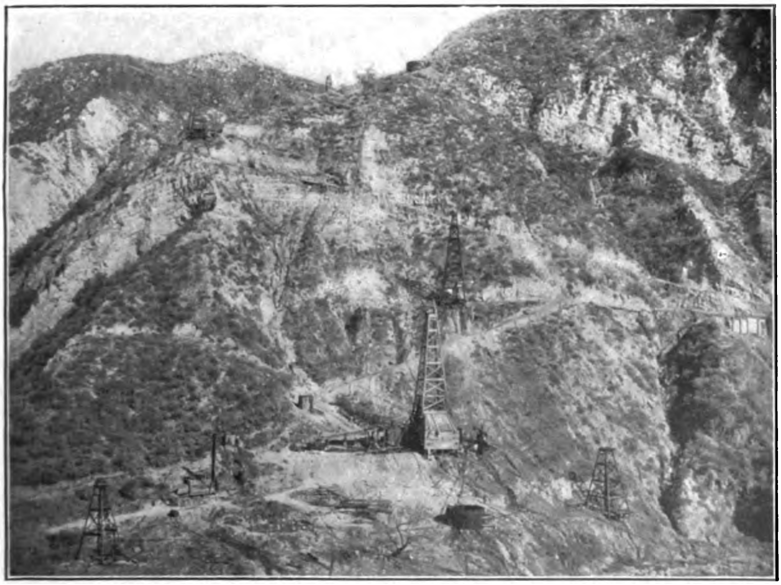
FIG. 9.—Sketch map showing location of Fortuna wells with relation to the anticlinal axis. Heavy dots, productive wells; small circles, abandoned wells. Figures indicate numbers of wells. (See Pl. VIII, *B.*)

The maximum yield of any one of the Fortuna wells as reported is 75 barrels per day, but it is now generally less than 10 barrels. The gravity of the oil is about 14° B. Much water is pumped with the oil, being separated in tanks at the wells. The oil is pumped to storage tanks on the line of railway about 2 miles distant.

The accompanying sketch (fig. 9) illustrates the general distribution of the wells with respect to Hopper Creek and the axis of the anticline.



A. MODELO WELLS, MODELO CANYON, VENTURA COUNTY.



B. FORTUNA WELLS, HOPPER CANYON, VENTURA COUNTY.

NIGGER CANYON WELLS.

The three wells in Nigger Canyon are owned by L. H. Lyon, of Los Angeles. They are located at the head of the southern of the two east forks of the canyon and start in strata which are close to the line of division between the upper Modelo sandstone and the underlying shale—that is, they penetrate a zone which is practically the same as that from which the Fortuna wells obtain their oil. Their depth is approximately 1,000 feet. Oil springs occur in the immediate vicinity and may have determined the selection of this territory for drilling. The wells are close to the axis of a prominent anticline, which is perhaps one of the leading secondary folds north of Santa Clara River. This fold has an apparent length of about 5 miles, but no wells except these have been drilled upon it. Its trend in general is about N. 80° E., but varies somewhat from point to point. Toward the east, in the direction of Piru Valley, this fold has the appearance of passing into the Modelo anticline or one of its minor crumples. To the west it is traceable beyond Hopper Canyon, where it becomes more or less obscure in the great body of shale which separates the two principal Modelo sandstones and where it comes into close proximity with one of the important northwest-southeast folds that extend from this point westward to Sespe Canyon. Of the Nigger Canyon wells, Nos. 1 and 3 are a short distance south and No. 2 is immediately north of the axis of the anticline, which at this point trends N. 83° W. These wells are from a year to three and a half years old. Nos. 1 and 3 yield each 5 to 8 barrels per day, but No. 2 was flooded with water, which has prevented its being in service. It is reported that in No. 3, at a depth of 65 feet, a body of asphalt was encountered, which drilled with difficulty. It was hard at the top and of the consistency of maltha at the bottom, and is supposed to have filled a fissure in the shale. The oil was found at intervals from a depth of 10 feet to the bottom of the wells. Gas occurs in small amounts, and water to the extent of about one-third of the oil has been encountered.

MODELO CANYON WELLS.

The structural feature of chief interest in Modelo Canyon is an anticline in which the lower Modelo sandstone is sharply folded as diagrammatically represented in Pl. III, sec. X–Z′ and Pl. IV, sec. G–G′. The general aspect of the locality is shown in Pl. VIII, *A*. A second feature of minor importance is the succession of crushed folds, with faults, at the head of the south fork of the canyon, one-fourth to one-half mile south of the anticline.

The Modelo anticline has already been referred to, notably in the general description of the geology of the region between Hopper and

Piru creeks. Nowhere, however, is the fold more perfectly and symmetrically developed than at the head of Modelo Canyon, nor is the lower Modelo sandstone anywhere more typically represented than in this region. The exact horizon of the sandstone that outcrops at the divide between the east and west drainage is probably in the lower half of the sandstone member, but owing to the steepness of the dip on both limbs of the anticline, amounting to 70° or 80°, it is questionable if the wells have penetrated to the base of the formation, although a depth of 1,500 feet has been attained.

The length of the Modelo anticline is somewhat uncertain; to the west, beyond Hopper Canyon, it may pass into one of the folds of that region, while to the east it may prove to be continuous with the anticline that lies immediately south of Holser Canyon. The Modelo wells are located about the middle of this fold and on either side of its axis. This is one of the few instances in the Coast Range where oil wells have been developed midway of a fold or in such close proximity to its axis. It may be worthy of note that the Modelo anticline lies but a short distance north of a line of sharp crushing and folding, thus repeating a relationship between the productive anticlines and faults that has been established in several of the California fields, notably those of the Puente Hills. The developed area of this district is thus far confined to the lower Modelo sandstone, but the structure is continued eastward into the overlying shale and the upper sandstone.

The relative positions of the wells along this anticlinal fold in Modelo Canyon, considered with the depths at which oil is obtained, are of interest; for instance, between the lowest and the highest well there is a difference in altitude of nearly 800 feet; between well No. 18, the lowest, and No. 19, at an elevation slightly below the highest well, there is a distance of perhaps 700 feet; in No. 18, with a depth of 1,090 feet, the lowest oil occurred at 930 feet; in No. 19 the lowest oil was found at 805 feet, at the bottom of the well. This would indicate a curve of the oil table, which corresponds somewhat with the slope of the present surface along the anticline.

The general trend of the axis of the Modelo anticline is but 3° or 4° north of west, although in approaching Hopper Canyon and the valley of Piru Creek the direction becomes N. 80° W.

The wells of the Modelo Oil Company number 24. One is drilled directly in the divide between Modelo and Hopper canyons, two a short distance west of this divide, and the remainder east of the divide for half a mile down Modelo Canyon. The accompanying three logs from the records of the company have been selected to show the composition of the Modelo sandstone. Well No. 14 lies near the middle of the group, No. 24 is about 500 feet west of the divide, and No. 18 is the easternmost well in the proved area.

Logs of wells of the Modelo Oil Company, Modelo Canyon and vicinity.

WELL NO. 14.

	Thickness.	Depth.
	Feet.	*Feet.*
White sand	190	190
Oil sand (oil)	210	400
White sand	60	460
Oil sand (oil)	70	530
White sand	70	600
Oil sand (oil)	35	635
White sand	75	710
Oil sand (oil)	70	780
Water sand	40	820
Oil sand (oil)	50	870
Water sand	10	880

WELL NO. 24.

Sand rock	115	115
Adobe	5	120
Clay	25	145
White sand	10	155
Adobe	15	170
Sand rock	10	180
White sand	315	495
Sand and adobe	45	540
Adobe	5	545
Oil sand	50	595
Water sand	25	620
Sand and adobe	70	695
Oil sand (oil)	10	705
Sand rock	50	755
Sand and bowlders	120	875
Hard sand	20	895
Water sand	60	955
White sand	15	970
Oil sand (oil)	42	1,012
Hard sand	23	1,035
Sand and adobe	75	1,110
Oil sand (oil)	35	1,145

WELL NO. 18.

Blue sand	121	121
Gray sand (oil at 160 feet)	39	160
Black shale	25	185
White sand	45	220
Black shale	30	250
White sand (water at 290 feet)	45	295
Black shale (water at 316 feet)	35	330
White sand	50	380
Clay	28	408
White sand (gas and water at 495 feet)	132	540
Clay	20	560
White sand (oil at 870 feet)	310	870
Gray sand	35	905
Shale and sand (oil at 923 feet)	25	930
Asphaltic sand	5	935
Gray sand	65	1,000
Water sand (oil at 1,030 feet)	30	1,030
Clay	43	1,073
Water sand	17	1,090

The figures in the first column of the above log represent the distances for which each individual stratum was encountered. As the dip of the beds is between 65° and 80°, these amounts are far in excess of the actual thickness of the respective beds.

From the log of well No. 18 it seems probable that the thickness of the productive sands at the several horizons is slight.

The logs are given in the vernacular of the driller. It is probable however, that adobe and clay are one and the same, except that the former is perhaps somewhat more tenacious than the latter. Shale is distinguished from clay by being less sticky and more inclined to come up in minute slivers. The sands are distinguished by colors, but this feature is not significant. The water sands are those in which water has been encountered in drilling, and it is to be observed that they are in alternation with the oil sands, the two being in places adjacent; in places separated by a clay parting. Mr. Sperry, manager of the Modelo Oil Company, believes that at least a thin stratum of shale between such sands is the rule. It is difficult to explain the alternation of water and oil sands if consideration is given to the supposed transmigration of the oil from its seat of origin in the shales into the sandstones, which serve as reservoirs. It has been suggested that this alternating occurrence may be accounted for by considering each pair of layers—the oil above and the water below—as occupying an isolated channel or reservoir, the segregation having taken place after their entrance into the containing strata on account of the difference in specific gravity of the two fluids. Nearly all the wells periodically pump more or less water with the oil, at times in the proportion of 3 barrels of water to 1 barrel of oil, at other times in equal amount. The continuity of sands bearing water and oil need not be regarded as indicating that the two are mixed in their natural occurrence, but only that both flow into the well from the same bed, the oil perhaps resting upon the water in the reservoir.

The bowlders referred to in the log of well No. 24, between the depths of 755 and 875 feet, are unquestionably the concretions that characterize the lower Modelo sandstone.

The yield of the Modelo wells is between 5 and 15 barrels per day, and Mr. Sperry states that since 1897 there has been no perceptible decrease in the amount. Of course for the first few days the yield was considerably in excess of these figures. The oil is black and its gravity ranges between 25° and 32° B., with perhaps 28° as an average. The wide variation in gravity of the oil from these wells is a feature that is difficult to explain.

Strong seepages are found along the canyon in the débris that fills the bottom. The sandstone in the arch of the anticline also is dark, with bitumen contents, especially on the northern side of the axis.

WELLS OF THE PIRU OIL AND LAND COMPANY.

The productive wells of the Piru Oil and Land Company are located in the valley of Piru Creek, about 2 miles northeast of Piru. At present two wells yield oil and one water. They penetrate conglomerate and sandstone, with some clay, which are believed from their fossils to be the Fernando formation. The general dip of the strata is from

45° to 60° or 70° S. and the strike varies slightly on either side of east and west. The particular horizon in the Fernando is somewhat uncertain, by reason of the proximity of the wells to what appears to be a line of unconformity between this formation and the older Modelo beds. It is, however, undoubtedly well up in the Fernando, if the section across the hills in front of the wells and directly north of Camulos is to be taken as a criterion.

The structural position of the wells is also somewhat in doubt, for no anticline is encountered along the creek for the distance of a mile. On the other hand, there is within half a mile south of the wells a marked east-west disturbance, which has at one point the appearance of a syncline, at another of an overturn of the beds adjacent to a sharp crumple, and at still another of a fault. About half a mile northwest of the wells is the anticline, near the axis of which the Nigger Canyon wells are situated. It is possible that the effect of this anticline extends as far distant from its axis as this group of wells. They are from 300 to 600 feet deep, and undoubtedly their oil is derived from the conglomerate and sandstone of the Fernando, a horizon higher than any other yielding oil north of Santa Clara River.

The production of these wells is but a barrel or two daily of what is said to be 15° gravity oil. The oil is black and thick, and much water is pumped with it, separation being effected in tanks.

Several other wells have been drilled on the property of the Piru Oil and Land Company lying along Piru Creek, extending from the mouth nearly to Reasoner Canyon. These ventures, however, have not been crowned with success.

WELLS OF HOLSER CANYON.

Less than half a mile south of Holser Canyon is one of the more prominent anticlines that have affected the Fernando formation east of Piru Creek. The continuation of this anticline to the west was not determined, but from its position and trend it may pass into the Modelo fold; on the other hand, like so many other folds in this region, it may spring from the system west of Piru Creek, but maintain an independent position east of the stream.

Two wells, the Ramona and New Camulos, are located a little south of the axis of this anticline, in tributaries of Holser Canyon, and north of the canyon, between half a mile and a mile north of the axis, is the Crown King. None of these wells has yet found oil. The rocks of Holser Canyon are conglomerate and sandstone, with local beds of argillaceous shale. Some of the sandstone shows the presence of a considerable amount of bitumen throughout its mass and it is probable that drilling operations are conducted here on this account.

OIL FIELDS SOUTH OF THE SANTA CLARA.

GENERAL STATEMENT.

The oil fields south of Santa Clara River involve an area having an east-west length of 29 miles and a width of from one-half mile to 4 miles. For convenience of discussion the territory is divided into four fields, which lie at varying intervals along the front of Oak Ridge and the Santa Susana Mountains, none being yet developed on the slopes of South Mountain. Enumerated from west to east they are the Bardsdale and the Torrey-Eureka-Tapo fields, on the north flank of Oak Ridge; the Pico field, comprising Pico, Dewitt, Towsley, Wiley, Rice, and East canyons, along the Santa Susana Mountains; and the Elsmere field, containing the Elsmere and Placerita wells, on the spurs of the San Gabriel Range. (See Pl. V, p. 36.)

The fields are developed along the axes of the Oak Ridge, Torrey, Eureka-Tapo, Pico, and Elsmere anticlines. The Placerita wells are quite independent of the others and are located on the northward-dipping schists of the San Gabriel Range. The formations involved are the Sespe (Eocene); Vaqueros (lower Miocene); and Fernando (largely Pliocene). All of these are productive. In addition the schists of the San Gabriel Range afford some oil.

BARDSDALE FIELD.

LOCATION.

The Bardsdale field, as here described, includes South Mountain and Oak Ridge as far east as the vicinity of Chaffee Canyon. As all of the proved oil territory in the field lies north of the crest of the range the detailed descriptions will deal largely with the northern slopes.

GEOLOGY AND STRUCTURE.

The South Mountain-Oak Ridge anticline extends the entire length of the two ridges from which it receives its name. The axis is well down on the northwest slope of the mountains, in most places at a distance of less than half a mile from the edge of the Santa Clara Valley and locally but a few rods away. At the west the axis disappears beneath the valley filling a few miles from the end of South Mountain, leaving the extremity of this ridge wholly on the southern limb of the fold. At the east the anticline terminates abruptly against the northwest-southeast system of folds that sets in at Chaffee Canyon and continues thence eastward to Fernando Pass.

The trend of the anticlinal axis varies in sweeping curves between N. 65° E. and east and west, displaying a certain degree of parallelism with the nearer strikes and with at least one structural curve—that on the southern slope of San Cayetano Mountain, north of the Santa Clara Valley. While, therefore, the South Mountain-Oak Ridge-Santa Susana uplift is undoubtedly an independent unit of structure, its development was very probably synchronous with the mountain building to the north. Transversely the fold is unsymmetrical at nearly all points, the southern limb having much the gentler dip and the strata on this side of the axis showing less severity of crumpling than those on the north side. The axis of the anticline is also undulatory, the high points being midway of the length of South Mountain and of Oak Ridge.

A transverse section of the anticline at Sulphur Canyon, which practically marks the division of South Mountain from Oak Ridge, shows between 1,000 and 2,000 feet of conglomerate, sandstone, and shale that are probably Fernando, and at least 500 or 600 feet of chalk rock and siliceous shale which have been described as of the Modelo type, but concerning the proper stratigraphic reference of which some doubt has been expressed. The shale and "chalk rock" occur in the axis of the fold, while the conglomerate and its associated strata rest unconformably upon its southern flank, forming the higher portions of the ridges and extending far into the Simi Valley. On the northern flank the Fernando beds do not appear, the underlying shale extending to the Santa Clara Valley. The anticline is somewhat contracted in the region of Sulphur Canyon, and no beds older than those of Modelo type outcrop. A short distance to the east and west, however, the fold broadens perceptibly and lower formations are successively exposed.

In South Mountain the lowermost beds are red and gray banded sandstone and clay, which are tentatively regarded as the partial correlative of the Sespe beds north of the Santa Clara, and hence of Eocene age. The formation is here especially conspicuous for its brilliancy of coloring and the sharp contrasts therein. At least 500 feet of strata are exposed opposite Santa Paula, but the formation occupies the heart of the anticline and its total thickness may be much greater. Overlying these are other heavy sandstone and shale, resembling in general aspect certain phases of the chocolate-colored and gray-banded beds of the Vaqueros formation farther east and bearing fossils similar to those of the Vaqueros. Still higher are siliceous shale and "chalk rock" of the Modelo type, bearing not only the customary limestones of that formation, but also several beds of fine-grained, gray sandstone. The "chalk rock" is somewhat more conspicuous in South Mountain than farther east. The formation as a whole, however, shows the same general characteristics as in Oak Ridge, even to the red, lava-like appearance, the probable result of the burning of its petroleum content. The shale, with its brilliant colors, forms the crest of South Mountain, and extends for a considerable distance down its western slope. It is succeeded by the Fernando formation.

Minor crumples appear in South Mountain, but in the main the direction of dip is to the south, northerly dips being confined practically to the northern side of the anticline along the edge of the Santa Clara Valley.

East of Sulphur Canyon the anticline rapidly opens, and at Grimes Canyon (see Pl. III, sec. D–D′) it attains its greatest development. Here are exposed, in consequence, lower rocks than elsewhere—the deep-yellow sandstone that has been described as the possible correlative of the rusty beds in the upper portion of the Sespe formation north of Santa Clara River. It is overlain by red and gray banded beds, except on the north, where the valley has been eroded through these beds and into the older strata below. The yellow sandstone is also underlain by red and gray beds, as shown by the logs of the wells of the Bardsdale Crude Oil Company. Whether or not the heavy mass of red sandstone and conglomerate which constitutes the greater part of the Sespe formation north of the Santa Clara is present here at still greater depths is undetermined. The formations throughout give evidences of marked change within comparatively short distances, and it may be that the red beds of the Sespe have practically disappeared.

Overlying the red and gray beds are rocks which have been identified by their fossils as a portion of the Vaqueros formation, consisting of conspicuous and persistent sandstone at the base and summit, and chocolate-colored and gray arenaceous shale, with occasional bands of limestone between. They bend down over the anticline between Garberson and Wiley canyons, and west of a point a little west of the mouth of Shields Canyon are adjacent to the Santa Clara Valley. At Wiley Canyon the axis of the anticline presents a small core of the underlying red and gray beds. The outer body of the Vaqueros displays a slight syncline, a flexure that is the beginning, perhaps, of the more highly disturbed conditions that exist but a short distance farther east. A secondary anticline also occurs well up the slope of the mountain between Shields and Garberson canyons, with a length of slightly over a mile.

The Vaqueros is easily confused with the Fernando formation, as the sandstone and conglomerate of the two formations bear considerable resemblance. It is probable, however, that the Fernando does not appear west of Torrey Canyon, but from that point eastward it grows in importance to the east end of the Santa Susana Mountains, where it is very prominent.

Siliceous shale and "chalk rock" of the Modelo type overlie the Vaqueros and form the crest of Oak Ridge for nearly its entire length.

Although in South Mountain this formation appears to contain minor divisions of sandstone, these seem to be wanting in Oak Ridge. On the southern slope of the ridge, above the shale and unconformable with it, are the Fernando conglomerate, sandstone, and clay. These for the most part lie well down the slope of the mountain, but here and there reach the crest.

OIL WELLS.

UNION AND BARDSDALE CRUDE WELLS.

A single oil field has been developed in the South Mountain-Oak Ridge anticline. It lies opposite Bardsdale, extending along the axis of the fold from Grimes Canyon westward for a mile and a half. Two companies are operating—the Union Oil Company and the Bardsdale Crude Oil Company. The territory of the former is adjacent to Grimes Canyon; that of the latter is the westward extension of the field. The wells of these companies are sunk in the rusty-yellow conglomeratic sandstone described as the lowermost formation of this district and possibly of Eocene age. The wells are located along the highest portion of the anticline, the elevation of any particular bed diminishing in both directions along the axis of the fold. The records of the wells indicate that oil is found in the rusty sandstone and in the underlying red and gray sandy beds at depths of 300 to 815 feet. The total depth of the wells varies from 500 to 1,000 feet. The oil is black and its gravity is reported as ranging from 23° to 32° B., the average being about 30°. In one instance an oil of about 17° B. was encountered. Occasionally water is pumped with the oil, but this is exceptional where a good landing stratum is obtained for the casing. Such a stratum is usually found among the red bands of the beds underlying the rusty sands. These, being generally more argillaceous than the gray bands, afford a more nearly water-tight bed. The wells of the Union Oil Company have been steady producers for a number of years, the decrease reported to the writer being but slight. These wells yield a large quantity of gas, which is used entirely for fuel. Of the total number of wells the Union Oil Company pumps about fifteen, the Bardsdale seven. The foreman of the Union Company remarks that if the gas be retained in one of the two strings pumped by them the wells of the other have an increased product, and that if the gas is not taken from the wells the pressure in them becomes so great as to hold the oil back. Numerous devices have been used for drawing out the oil, one of them being the ordinary steam ejector.

At several other points in the Oak Ridge anticline wells have been drilled, but without success. This may be due in part to insufficient depth and in part to their location beyond the oil zone. In Garberson Canyon, for instance, a well has been drilled to a depth of over

1,800 feet, producing nothing but water. In Shields Canyon, however, west of Garberson, a trace of oil was found at 500 feet, the total depth of the well being 850 feet. The gravity of this oil is said to have been 29.5° B., but much water was encountered with it.

TORREY-EUREKA-TAPO FIELDS.

LOCATION.

The district discussed in the following paragraph embraces Oak Ridge east of Chaffee Canyon and the western portion of the Santa Susana Mountains as far east as the head of Tapo Canyon. Within it are three productive areas—those of Torrey, Eureka, and Tapo canyons.

GEOLOGY AND STRUCTURE.

As will be gathered from the description of the geology of the Bardsdale district, there is a marked regularity in the stratigraphic succession of the formations and in the anticline into which they have been thrown from the west end of South Mountain to Chaffee Canyon. Here, however, the regularity ends. The region between Chaffee and Tapo canyons shows a highly complicated geologic structure, and there is great confusion in the stratigraphic succession, resulting from the presence of folds and faults and the difficulty of distinguishing between formations, owing to a lack of distinctive characteristics in the beds and to changes in the relative proportions of the coarse and fine sediments from point to point.

The first break in the regularity that exists to the west appears in a small gulch at the foot of Oak Ridge immediately west of Chaffee Canyon. At this point the end of what for convenience may be termed the Chaffee syncline appears in "chalk rock," siliceous shale, and limestone that are believed to be of the same formation as similar rocks which form so great a portion of the summit of Oak Ridge, having been brought into this position, almost at the edge of the valley, by arching over the axis of the Oak Ridge-South Mountain anticline. The general trend of this syncline is about S. 30° E., the dip on either side averaging perhaps 35°, although steepening sharply as the axis is approached. The syncline increases in prominence as it crosses the drainage of Chaffee Canyon, and at the summit of the ridge at its head becomes a conspicuous feature in the crest line. The details of this syncline have not been gathered in full, but apparently the heavy fossiliferous sandstone which outcrops in bold escarpments in Wiley Canyon plunges beneath the axis to reappear on the northeast side in the ridge that separates Chaffee and Torrey canyons. The conditions observed in Chaffee Canyon suggest that only the lower beds of the siliceous shale and "chalk rock" are involved in the fold, although at the southeast end of the syncline, on the southern slope of Oak Ridge, a considerably greater thickness has been folded in.

The direction of the Chaffee syncline is at variance with that of every other fold that has been observed in the ranges south of Santa Clara River. Moreover, it lies between two systems of folds, either of which might be said to terminate against it. One of these systems includes the anticline traceable from Wiley Canyon westward to the end of South Mountain; the other is that passing from the region of Torrey Canyon in a S. 65° E. direction to the west end of the Santa Susana Mountains. It is worthy of note, too, that the position of the Chaffee syncline is nearly in direct line with the principal fault in the hills north of the Santa Clara.

In the region of Torrey and Eureka canyons the geology is extremely complicated, but the general facts appear to be as follows: The formations exposed include 150 or 200 feet of red and gray banded sandstone and arenaceous clay of the Sespe, about 600 feet of fossiliferous sandstone and chocolate-colored and gray sandstone and shale of the Vaqueros, perhaps 400 feet of siliceous shale and chalk rock of Modelo type, and a great body of heavy-bedded sandstone and conglomerate, in some of which have been found fossils identifying them as the Fernando (Pliocene). These formations are shown in a section of Oak Ridge across the Torrey field—the oldest beds at the heart of an anticline at the northern edge of the productive area, the youngest on the southern slope of the ridge and again at its northern base, the siliceous shale and "chalk rock" at the mountain crest, and the Vaqueros on the upper and lower middle slopes of the northern front.

The structural lines of the Torrey field have a trend approximating N. 65° W., contrasting in this respect with those of Oak Ridge to the west and in harmony with those to the east, the dividing line between the two systems being the Chaffee syncline, already described.

The principal fold of the Torrey field (see Pl. IV, sec. H–H′) is an anticline that crosses the ridge between Torrey and Smith canyons at the summit of the easterly grade leading to the developed territory. This anticline has not been traced eastward to the edge of the Torrey basin, but directly in line with it at this point is a similar fold, which is probably its continuation. To the west the anticline crosses Torrey Canyon, being particularly conspicuous in its lower slopes, becoming less so in the ridge between Torrey and Chaffee canyons, and disappearing to a mere trace in the lower portion of Chaffee Canyon as it approaches the Chaffee syncline. The trend of this anticline, which may be designated the Torrey, is N. 65° W. The inclination of the strata on either limb varies from point to point, but in general may be taken at about 35°. Southward from the axis the dip is comparatively regular to a point beneath the summit of Oak Ridge. To the north, however, the dip continues but a short distance when it gives way to a southerly dip, the syncline thus formed being hardly less conspicuous than the anticline itself.

The formations exposed in the Torrey anticline include, at the axis, a small outcrop of red and gray banded beds, believed to be the Sespe formation; overlying these is the principal formation of the field, heavy sandstone and chocolate-colored and gray-banded shales, which, by their fossils, have been identified as lower Miocene (Vaqueros), nearly 1,000 feet thick; succeeding these, on the south the siliceous shale of the Modelo, which forms the crest of Oak Ridge opposite the Torrey field, and on the north—the siliceous member apparently being wanting—the heavy sandstone and conglomerate that are regarded as the Fernando. The Fernando is, however, of small extent in this vicinity, becoming prominent in the region of Tapo Canyon and attaining its maximum development several miles farther east, opposite Pico Canyon and beyond.

A second anticline in the Torrey field lies in the lower slopes of the hills and is probably the west end of that believed to exist along the channel of Eureka Canyon, this, in turn, being continuous with the main Tapo anticline farther east. This fold may be seen to advantage in the west wall of Torrey Canyon, midway between its mouth and the forks half a mile up. East of this the flexure is not quite so pronounced and is, therefore, not so readily and perhaps not so correctly defined. Between Eureka and Torrey canyons the axis of the fold pitches to the west, while the strike of the beds is generally north and south. There is considerable doubt concerning the structure and the succession of the strata in Eureka Canyon. At first glance the regularity appears to be unbroken from the crest of Oak Ridge to the outer face of the lowermost foothills, the entire cross section, except at the summit of the ridge, presenting a southerly dip. From the region of Tapo Canyon, however, the main anticline may be traced with only slight irregularities to the divide between the Tapo drainage and that of Eureka Canyon, but at this point there is a sharp change in the position of the strata, as if the anticline had been severely compressed and the plane of its axis had been pushed northward with a dip of perhaps 60° to 90° to the south. (See Pl. IV, sec. I–I′.) In the higher portions of Eureka Ridge, a short distance north of this anticline, there is a syncline of secondary importance, which also has probably suffered strong compression. The resultant position assumed by the beds thus influenced by the compound flexure described is one of southerly dip, with local obliteration of the axes of both folds, and an apparent continuous succession of strata from base to summit of the mountain. It is evident, however, that if this should prove to be the correct structure there is a duplication of beds in the cross section referred to. At the mouth of Eureka Canyon there is an exposure of Fernando conglomerate and sandstone, bearing fossils identifying them with the beds of Packard Hill, near Santa Barbara. Their dip is vertical, the change from the southerly dip of the older strata immediately south being somewhat abrupt. This is probably due to unconformity rather than to a structural break. The Eureka-Tapo anticline appears to be coextensive with the Torrey, a mile to the south. Neither has been traced from one end to the other, as delineated on the map (Pl. I), but by reason of the alignment of several folds observed independently it is thought that all are parts of a single crumple. As in the case of the Torrey anticline, productive territory has been developed in proximity to the axis of the Eureka-Tapo fold, the western field being that near the mouth of Eureka Canyon, the eastern including several branches of Tapo Canyon.

Between the two anticlines thus described is a syncline which has not been traced through from west to east, but which is supposed to be continuous, as represented on the map. It may be seen on both sides of Torrey Canyon, but in the eastern wall of Smith Canyon the fold, which is so pronounced to the west, is considerably obscured, perhaps by faulting along its axis. A sharp disturbance of the strata is recognizable in a vertical cliff of shale and sandstone directly across Smith Canyon from the easterly grade to the Torrey wells. In the line of the syncline, also, there is a similar flexure near the summit of Oak Ridge, and this in turn is in line with the Tapo syncline, a flexure a few hundred yards south of the main anticline in Tapo Canyon.

There are other folds of minor importance in this region, here and there, sharp or even developed into faults of small extent. The larger folds that have been described converge near the mouth of Chaffee Canyon as they approach the Chaffee syncline.

The formation chiefly involved in the flexures of the Torrey-Eureka region is that of Vaqueros age. To the south in the higher portion of Oak Ridge the siliceous shale of Modelo type is also involved in a minor degree. On the southern slope of the main ridge, near the Torrey road, the general dip, aside from numerous minor crumples, is northward, and a short distance north of the outcrop of the Fernando formation a sandstone suggesting one of the Vaqueros beds occurs in a position not at all out of harmony with the general structure. The actual correlation of this bed, however, remains undetermined and it has not been indicated on the map. North of the Vaqueros area, at the foot of Oak Ridge, is the Fernando, which also is involved in the general folding that has taken place.

It is possible that faults occur within the area of the folds referred to in the foregoing paragraphs. The greatest disturbance appears to have been in the line of the syncline separating the Torrey and

Eureka-Tapo anticlines, in the eastern rim of the Torrey amphitheater, the facts pointing to an elevation of the strata north of a possible plane of fracture.

The Tapo anticline is traceable for 3 or 4 miles across the northern spurs of the easterly portion of Oak Ridge, its axis lying from one-half to two-thirds the distance from base to summit. The general trend of the fold is about N. 70° W., the dip of the strata on either side of the axis varying between 75° and 85°. The heart of the anticline is occupied by a mass of brown shale and interbedded concretionary sandstone. These are believed to be the equivalents of the banded chocolate-colored and gray sandstones and shales in the vicinity of Wiley Canyon and farther west, and, if such is the case, are of Vaqueros age. On the other hand, the concretionary phase of the sandstone resembles the lower Modelo formation north of the Santa Clara, but no fossils have been found to decide the point. Many of the sandstones of Tapo Canyon are highly bituminous, and along the crest of the flexure in the several forks occur seepages of petroleum of considerable size. In the main canyon, either on the axis or slightly to the south of it, is a gas well, but its depth and the horizon from which gas is derived are unknown.

The Tapo anticline appears to die out toward the east in a mass of crushed strata at the head of the westernmost branch of Salt Creek on Santa Susana Mountain. In a westerly direction the geologic conditions are somewhat uncertain, but in the ridge separating West Tapo and Eureka canyons the axis has the appearance of bending rather sharply to the north. On the other hand, as already suggested, the geology of Eureka Canyon and the adjacent slopes is very complicated, and for a definite conclusion concerning the relations of the thousands of feet of very similar beds additional field work is necessary. The position of the Tapo anticline is but tentatively indicated on the map (Pl. I).

Between 100 and 200 yards south of the Tapo anticline is a syncline which is pronounced in the region of the main forks of Tapo Canyon, but which west of this disappears in the general crumpling on the higher slopes in front of Oak Ridge. In an easterly direction its axis approaches that of the anticline, and both are apparently lost in a common mass of crumpled strata at the end of the Santa Susana Mountains.

The zone of excessive crumpling, embracing the Torrey and Tapo anticlines and their associated synclines, passes from Oak Ridge into the west end of the Santa Susana Mountains, in part also crossing the crest of the range at the low point opposite the head of Tapo Canyon. In the region thus indicated the disposition and succession of the strata are very anomalous, and from a topographic standpoint there is a distinct offset in the alignment of the two ranges, the west end of the Santa Susana lying a little farther north than the east end of Oak Ridge. The topographic relation of the mountain ridges may be due to the development en échelon of successive anticlines, but the anomalies of stratigraphy suggest the presence of a strike fault a little south of the Tapo syncline. For instance, in the northern slope of Oak Ridge between the Eureka and Tapo drainages, the apparent succession of beds is quite the reverse of the normal. Both the siliceous shale of the Modelo and the chocolate-colored shale and sandstone of the Vaqueros maintain a northerly dip, and the inference is that the latter are the younger. It is probable, however, that along the line indicated there has been displacement, the strata south of the fracture plane having been depressed, though to what extent is yet undetermined. This would agree with the explanation already suggested of the positions assumed by beds about the head of Smith Canyon. South of the Santa Susana Mountains the line of the fault is marked by great complexity of strata, it being impossible to recognize horizons and, in consequence, the relations of the beds. The fault plane from Tapo Canyon eastward appears to lie somewhat diagonal to the general trend of the formations; the area of siliceous shale, a prominent feature to the west, is diminished almost to disappearance, and the difficulty of correctly interpreting the structure is even further enhanced by the approach of the line of unconformity between the Vaqueros and Modelo beds and the Fernando formation. The Vaqueros beds are, however, chiefly involved in the crushing south of the range crest: The breadth of the zone of severely crushed and folded strata is hardly less than a mile, while its continuity can be traced for a distance of at least 10 miles.

The axis of a somewhat prominent anticline, trending a little south of east, passes through the knoll at the southeastern extremity of Oak Ridge, about three-fourths of a mile north of the parallel 34° 20′ N. and 2 miles west of the meridian 118° 40′ W. The eastern half of the fold involves the Fernando formation, but the western half lies almost wholly within the area of siliceous shale, though not far from the northern edge of the Fernando. The general trend of the axis is more nearly east and west than the direction assumed by the zone of crumpling. These two features therefore diverge toward the west, the zone of crushing and fracture turning to the north of Oak Ridge, the anticline passing to the south.

In addition to the foregoing, there are many other minor crumples of greater or less breadth and linear extent, particularly within the area of siliceous shale. All have a general direction of S. 70°-85° E., but their continuity has not been traced out.

The formation in the middle fork of Tapo Canyon from which oil is derived is a succession of sandstone and shale. The sandstone is generally thin bedded, and its proportion to the shale diminishes toward the base of the series. Concretions, some of them comparatively large and rounded, characterize certain horizons. The shale is for the most part earthy or sandy, but through it may be traced bands of harder and in some places even siliceous rock. Limestone concretions are also sparingly present. Both shale and sandstone have been more or less impregnated with petroleum, as well as with iron and salts of other minerals. Along the axis of the anticline, wherever crushing has been particularly severe, occur important seepages of petroleum.

Overlying the thin-bedded sandstone and shale, with comparatively sharp passage from the one to the other, is heavy-bedded sandstone divided by minor layers of sandy shale. The sandstone is gray to yellow in color, although yellow appears to characterize more generally the lower beds. The sand is coarse and locally gritty or even pebble bearing. Well up in the mass conglomerate appears, becoming in the outer ridges of the Santa Susana Mountains, a conspicuous feature in the geology. The sandstone and shale in the lower 1,000 feet of this younger formation have been impregnated in varying degree with petroleum, and from some of them come seepages, indicating considerable richness. From one or another member of this group of beds is derived the oil in the producing wells of Tapo Canyon.

Conformability appears to exist throughout the succession of strata above described, from the lowest, encountered in the heart of the anticline, to the highest, observed at the outer edge of the range. It is difficult, therefore, to recognize any true basis on which to segregate the beds into distinct formations, yet in a broad way they are separable into a mass of conglomerate and associated heavy-bedded sandstone and shale which bear a distinct resemblance to the Fernando of other localities in the Santa Clara district on the one hand, and thin-bedded sandstone and shale of a siliceous character, which closely resemble the banded chocolate-colored and gray shale and sandstone farther west in Oak Ridge and the Modelo in the range north of the Santa Clara on the other. For the sake of mapping, the dividing line has been taken at the lower horizon of the heavier conglomerate in the main Tapo Canyon, a quarter to half a mile above its mouth, occurring somewhat farther up on the streams to the east and somewhat lower down on those to the west.

OIL WELLS.

The oil wells in the territory just described comprise, in order from west to east, the Torrey, Eureka, and Tapo groups, each being designated by the canyon in which they are drilled.

TORREY WELLS.

The productive territory of the Torrey anticline, forming what is known as the Torrey field, embraces an area of about 1 square mile, the length being twice the breadth and lying with the strike of the rocks, which gradually bend from N. 65° W., the direction prevailing on the side of the flexure, to northwest, north northwest, and north as the strata round its end. The axis of the anticline passes close to the northern edge of the field, the wells, with a few exceptions, having been drilled in the strata of gentler dip, 30° to 40°, south of the axis. In all there are between 50 and 60 wells, aligned in seven or eight concentric arcs, in accordance with the curves assumed by the outcropping strata. The wells nearer the axis penetrate the red and gray banded argillaceous sandstone that has been correlated with a portion of the Sespe formation, while those more distant are perhaps entirely confined to the sandstone and shale of the Vaqueros.

It is said to be usually impossible in this field to identify horizons in one well with those in another, even though the two locations are adjacent. The oil sands also vary in thickness from a few feet to 150, and even the thicker beds, it is reported, can not be identified from well to well. It is, however, the opinion of the writer that considerable order might be worked out with the aid of carefully prepared cross sections.

The oil has a gravity of 30° to 35° B. and resembles that derived from the same formation north of the Santa Clara, especially that from the region of Fourfork and Tar creeks. The depth of the wells varies from 600 to 2,000 feet, the deeper wells being those farther away from the axis of the fold. North of the Torrey anticline the productive territory is apparently confined to the east end of the field where the distance from the syncline immediately north and from the fracture possibly accompanying it is greatest.

Concerning the extent of the Torrey field beyond the present developed area, it may be said with some degree of assurance that to the west and north it is likely to be limited by structural conditions to nearly the existing lines. In the other directions no prediction can be made.

EUREKA WELLS.

The wells of Eureka Canyon are located in its lower reaches, most of them being grouped at the sharp turn half a mile above its mouth. The geology of the immediate region is somewhat doubtful, but if the structure is that of a highly compressed compound fold, as suggested on page 82, the locus of the wells is not far from its anticlinal axis; moreover, the developed territory is in the vicinity of a prominent curve in the stratification planes, the axis having been pushed somewhat northward between Eureka and Torrey canyons. The wells penetrate the Vaqueros sandstone, conglomerate, and shale, but whether any of the beds are duplicated it is impossible to determine. Such duplication may have taken place, but it has had practically no effect on the productiveness of the territory. The wells are located a little over a mile north northeast of the Torrey group, the geology of the two fields being quite distinct.

Twenty-one wells were in operation or drilling at the time of the writer's visit. They vary in depth from 600 to 1,200 feet, and the strata passed through, according to the logs, embrace sand, arenaceous shale, dark, adobe-like clay, and the usual "hard shells" of the drillers. The character of the beds varies every 50 to 125 feet in depth, but sandstone predominates. Oil sand, so-called, appears to be encountered at depths of 540 to 620 feet. Water is found both in the upper parts of the wells and beneath the lowermost oil sand recorded. Well No. 20, of the group at the turn of the canyon, is the only one in which pebbles are reported. These are, perhaps, a local development of one of the more prominent sandstones that lie near either the summit or the base of the Vaqueros beds. Usually but a single oil sand shows in a well, and it is the opinion of the superintendent that the producing horizon is the same throughout the field.

The gravity of the oil averages, it is said, 24° B., but in some instances rises to 26°. This difference, as compared with the Torrey oil, is inexplicable, for both are believed to be derived from the same formation. Their horizons, however, may be different, and in the Eureka field the sediments appear to be coarser, while the strata are far more fractured, if the interpretation of the geology here given is correct. The latter feature would tend to permit the easier escape of the lighter hydrocarbons, leaving behind the heavier oils, which now constitute the product.

The yield has been from 1 to 40 barrels per day. The field has, however, never been one of large production, but from the records the wells appear to have maintained their supply with remarkable uniformity. The log of one of these wells is appended:

Log of well in Eureka Canyon.

	Thickness.	Depth.
	Feet.	*Feet.*
Sandy shale and "adobe"	50	50
Gravel, with water	25	75
Dark, black "adobe"	265	340
Arenaceous shale	135	475
Soft sand	50	525
Blue, caving shale, with thin sands interlaminated, becoming solid at 580 feet	35	570
"Hard shell," this marking the top of the oil sand, according to the driller's statement. At this point, also, water is shut off	15	585
Oil sand	10	595
Water sand with gravel distributed through it (abundance of water, no oil)	245	840
Soft, blue sandy shale	160	1,000
Coarse gravel (water)	127	1,127

No evidence of the red and gray banded series of probable Eocene age has been found in any of the holes in this field.

TAPO WELLS.

Wells have been drilled in the main fork of Tapo Canyon and also in each branch of a westerly tributary. Those at present producing lie along the east fork of this tributary. They are four in number, although from their designation, Nos. 12 to 15 inclusive, it is to be inferred that several others have been in existence in earlier days. Indeed, one or two of these old wells still contain a slight amount of oil. The producing wells are sunk in northward-dipping sandstone and shale a mile north of the axis of the Tapo anticline. They yield at present from 5 to 40 barrels of oil per day. The gravity is 20° to 24° B., the 20° oil being produced by the well highest up in the canyon and lowest as to the strata penetrated. These wells are about 200 feet apart and range in depth from 460 to 1,200 feet. The oil sand is encountered at 235, 465, 940, and 865 feet, from the well farthest up the creek to that lowest down, respectively. The wells lowest on the dip are the greatest producers. The dip of the measures is from 50° to 60°, and it is impossible to say that a single bed produces oil for the entire field, although this is suggested by the increasing depths of the wells in the direction of the dip. More or less water is pumped with the oil, and it is the opinion of the superintendent that the two are mined and come from the same bed. The amount of water, however, is slight, the proportion being given as 1 of water to 40 of oil. Inasmuch as water-bearing sands overlie the oil sands it may be that a leak occurs which would account for its presence with the oil. Water was also found beneath the oil sand in the well farthest up the gulch and has been encountered in some of the wells now abandoned. All the wells yield gas, the deeper the well the greater the quantity.

The whole of the lower half of the Vaqueros strata exposed in Tapo Canyon shows a greater or less impregnation with petroleum. No unusual amount appears to have been assembled in proximity to the axis of the main anticline, and it may be that the productive territory is a particularly rich portion of the series of beds which, from some cause or other, has held its oil better than the great mass of the beds in the region. From the surface no reason can be seen for the enrichment of one portion of the formation over another portion, and except for strong seepages in proximity to the wells one locality might as readily have been chosen for development as another.

The logs of the Tapo wells show a succession of blue clay, brown shale, gray sandstone, fine to coarse, and in one instance a trace of conglomerate. The thicknesses of these several materials, which are constantly repeated, vary from 5 to 200 or more feet, the average being, perhaps, between 20 and 75 feet.

PICO FIELDS.

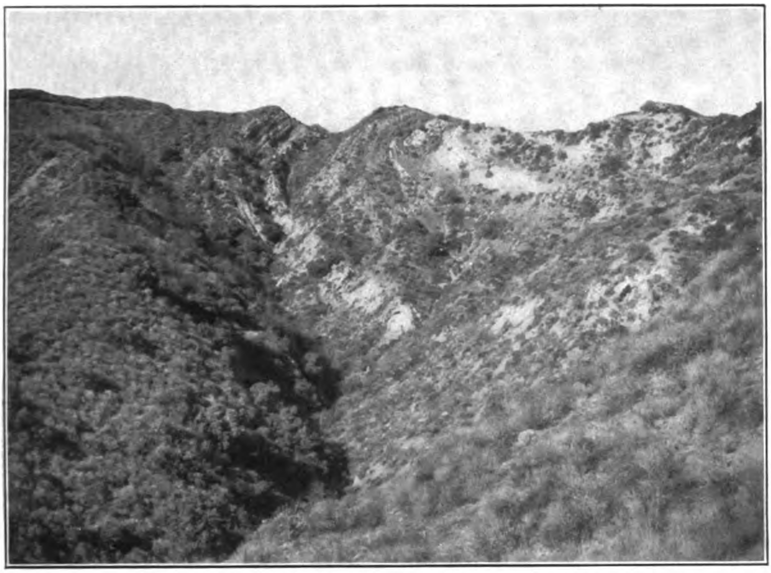
LOCATION.

The Pico district, the western part of what is popularly known as the "Newhall district," comprises the region of the Santa Susana Mountains from Tapo Canyon to Fernando Pass. The Newhall district is divided into the Pico and Elsmere districts for the purpose of this discussion, the geologic conditions in the two subdistricts being quite different.

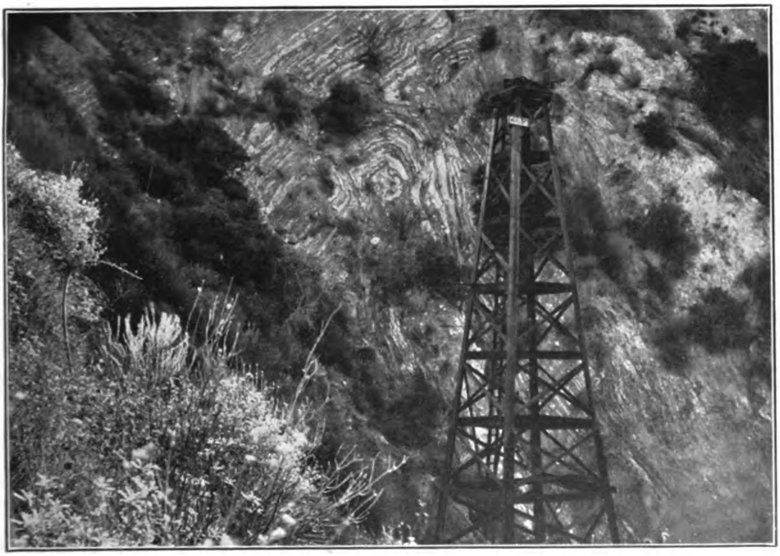
GEOLOGY AND STRUCTURE.

In the body of the Santa Susana Mountains there are many flexures in the siliceous shale of the Modelo and in the shale and heavy sandstone of the Vaqueros. Certain of these flexures along the northern front of the range have become of primary economic importance from the development of rich oil-bearing territory adjacent to their axes. With these alone the following pages have to do. (See Pl. IV, secs. J–J′, K–K′, L″–L–L′, and M″–M–M′.)

Chief among such folds is one which may be designated the Pico anticline. This extends for perhaps 10 miles along the northern front of the range. Its trend is N. 60° W. and the strata on the southern limb dip 25° to 30°, on the northern limb 50° to 70°. At the west the anticline originates in the divide between the waters of Pico and Salt canyons. The east end passes out of the range a mile or so south of Fernando Pass, the actual terminus being apparently in the foothills of the San Gabriel Range, or in the valley edge immediately adjacent. The axis of the anticline may be seen in any of the canyons of the Santa Susana Mountains draining to the Santa Clara. (See Pl. IX, *B*.) Its trend is somewhat irregular, though in its entirety the fold maintains the direction given very closely. In the hills between Dewitt and Pico canyons a minor fold of the same nature branches off to the north, but this in few places amounts to more than a pronounced pucker in the beds affected by it. The Pico anticline is traceable at least to Wiley Canyon, and perhaps even to the forks of Rice and Gavin canyons. South of the main fold is a syncline which parallels it for its entire length. This originates at the west at about the same point as the anticline, in a mass of highly crumpled strata in the divide between Pico and Salt canyons. After a divergent course of 2 or 3 miles the anticline and syncline lie parallel with each other to the San Fernando Valley. At certain points along the syncline, as, for instance, at the head of Pico Canyon, there is some evidence that faulting has taken place immediately to the south, the strata south of the fault plane being downthrown and the plane itself inclined at an angle of 50° to 70°. The evidence, however, was not followed up,



A. OVERTURN IN VAQUEROS FORMATION, WEST SIDE OF PICO CANYON, LOS ANGELES COUNTY.



B. PICO ANTICLINE, PICO CANYON, LOS ANGELES COUNTY.

and on the map (Pl. I) the syncline is in the main given as unbroken. The similarity between this fold and the Tapo anticline is worthy of remark. In each case there is a principal anticlinal fold, with a parallel syncline on the south, and faults and a highly crushed zone in one instance and perhaps also in the other still farther south. The position of the Pico anticline is en échelon with that of the Tapo to the west and also with that of the Elsmere to the east, all being somewhat diagonal in trend to the general direction assumed by the ranges.

The strata involved in the folds described above and underlying the adjacent regions include a heavy deposit, presumably of lake beds, in the low hills about the junction of Santa Clara River and its tributary, Newhall Creek; conglomerate, sandstone, and clay of the Fernando, of a horizon possibly somewhat younger than that of the Fernando beds that lie immediately east of the mouth of Piru Creek; and a succession of brown and chocolate-colored shale, comparatively thin interbedded sandstone, and local conglomerate, which will doubtless prove to be of lower Miocene (Vaqueros) age, of the same horizon as the beds of similar nature in the region of Torrey and Tapo canyons and in the northern front of Oak Ridge farther west. The assumption that the beds last mentioned are lower Miocene is, in the absence of fossils, based on their lithologic resemblance to those of other localities in which determinative forms occur, on the presence of organic siliceous shale here and there in the beds of chocolate-brown color and of more earthy character, and on the occurrence of concretionary bodies, round to elliptical, in the sandstone of the formation. The shale and sandstone regarded as Vaqueros are confined to the heart of the anticline and to the regions adjacent which are affected by the subordinate folds in connection therewith. They occupy the entire front of the range to their line of union with the Fernando beds near the base.

The Fernando formation displays marked regularity of strike and dip, and from any of the high points within the range may be seen arching about the foothills from the vicinity of Newhall across Pico Canyon to the mouth of Salt Creek, bending in its trend from N. 50° W. to N. 75° W. A conspicuous feature of this formation is a great mass of bluish-gray clay that occurs a short distance above its base. It is particularly strong of outcrop in Road Gulch, perhaps on account of the gentle dip and wide erosion of this portion of the formation. The conglomerate which overlies this clay is heavily developed in beds from 50 to 300 feet thick.

The line between the Fernando formation and the beds regarded as Vaqueros is placed at the horizon of the uppermost brown or chocolate-colored shale. Conglomerate extends below this horizon, but not of the importance attained by those above. The manner of its occurrence is somewhat perplexing, for it is interspersed among the chocolate-colored shale and does not show the individuality of the two zones of heavy conglomerate that lie at the base and summit of this formation in the region of Wiley and other canyons to the west. Unconformity between the two formations probably exists, although angular discrepancies were not detected at any point in the Pico region. The absence, however, of the heavy mass of siliceous shale between the Vaqueros and the Fernando beds along the lower northern slopes of the Santa Susana Mountains is noteworthy. South of the Oak Ridge-South Mountain anticline, in the lofty upper escarpments, this shale attains a thickness of 300 to 500 feet and separates the Vaqueros from the Fernando conglomerate and sandstone on the southern slopes of the mountains. The absence of the siliceous shale in one locality and its presence in the other, notwithstanding the short interval between the two, suggest unconformity between the Fernando and the underlying beds. Moreover, there are several areas over which distinct unconformity is observable.

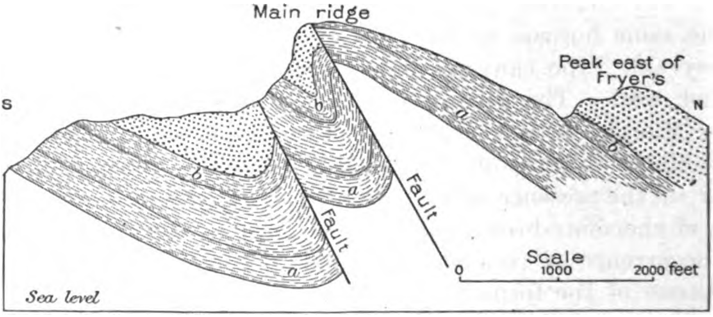


FIG. 10.—Section through Fryers Peak east of Fryer's ranch. Dots represent sandstone; fine lines, shale; a, b, beds of shale.

The Pico anticline has proved one of the most productive folds in the Santa Clara Valley. It exhibits marked regularity; the fold maintains a comparatively uniform elevation from west to east for nearly its entire length, and the beds involved are of uniform texture and uniformly disposed with reference to one another and to the axis of the fold. The inference seems natural, therefore, that such conditions would be favorable to the extended field that has been developed.

The northern slope of the Santa Susana Mountains presents considerable regularity in the succession of beds from the crest nearly to the line of the Pico oil field, but to the south of the crest, especially in the area opposite the Salt Creek drainage and the more easterly tributaries of the Tapo, there is a conspicuous crumpling in a zone half a mile wide, trending N. 70° W. The most severe crushing is to be seen immediately beneath the summit of the range, where in the chocolate-colored shale and its accompanying sandstone of the Vaqueros two or three anticlines, with their intervening synclines, occur in close succession; indeed, surface conditions suggest faulting similar to that shown in fig. 10. Within this zone or possibly slightly south of it is a dry well, the depth of which is unknown to the writer. The linear extent of the zone is unknown, but disturbance of the strata may be detected as far as the divide between the Simi and San Fernando valleys, and this series of fractures may prove continuous with the great fault suggested by the Whitney survey as south of at least the eastern half of the Santa Susana Range.

It is very evident that there is a pronounced unconformity between the Fernando conglomerate, sandstone, and clay and the older formations of Miocene, Eocene, and Cretaceous age south of the Santa Susana Mountains. The line dividing the Fernando from the older formations is, however, indicated only in a general way on the map, for the region was not studied with a view to geologic detail, being somewhat beyond the areas of developed oil fields.

PRODUCTIVE FIELDS OF THE PICO DISTRICT.

The productive fields of the Santa Susana Mountains, enumerated from west to east, include those of Pico, Dewitt, Towsley, Wiley, Rice, and East canyons, all on the northern slope. With the exception of those in Dewitt Canyon, which are apparently on a secondary crumple, all are ranged along the main Pico anticline, some to the north, others to the south of the axis. The anticline apparently maintains a uniform elevation except at the extremities, where it pitches east and west, respectively. This uniformity of level may account for the fact that the anticline has been found productive for so large a proportion of its length. This is in marked contrast to the development along the Oak Ridge anticline, the axis of which is decidedly undulating and which has been proved productive only at its point of maximum elevation opposite the town of Bardsdale. Doubtless many other factors enter into the explanation of the relative productiveness of the two anticlines, but the conditions above mentioned are to be considered in any attempt to account for it.

Only a single formation, the Vaqueros, is present in the productive oil fields of the Santa Susana Mountains. Its correlation is based on lithologic similarity to recognized lower Miocene beds of other localities, no fossils having yet been found in it in this district. The strata include a large proportion of brown argillaceous and arenaceous shale, much interbedded sandstone, and considerable conglomerate. Brown and white bands, a feature characteristic of this formation from Chaffee Canyon westward, are far less conspicuous in front of the Santa Susana Mountains, but conglomerate has a much greater development. As elsewhere, the shale includes at short intervals thin strata of a siliceous nature and limestones that are more or less concretionary. The sandstones and sandy shales are also concretionary, and here and there a bed may be found which bears a striking resemblance, except for thickness, to the lower Modelo sandstone north of the Santa Clara. The entire series has been more or less impregnated with bitumen, to which is probably due, in a large degree at least, its brown color. Except for local variation in the materials composing these beds, there is considerable regularity in their appearance as a whole, and the general succession is comparatively well maintained from one end of the region to the other. The local irregularities in composition, however, render it next to impossible to correlate the logs of wells a mile or more apart along the anticline. The dips are steep in many places, yet the crushing that is found in the region of Tapo and Torrey canyons is here wanting.

OIL WELLS.

PICO CANYON WELLS.

The wells of Pico Canyon, which belong to the Pacific Coast Oil Company, are located not far from the west end of the Pico anticline, which terminates in the divide between Pico and Salt canyons. In the western half of the productive territory the axis of the fold has a distinct pitch to the west. Between 40 and 50 wells have been drilled in the field, some more productive than others, but nearly all yielding at least a few barrels of oil. With the exception of three at the upper forks of the canyon, all are on the northern limb of the anticline, not far distant from the axis. They are sunk not only in the canyon, but even on the summits of the sharp knobs on either side of the gorge, the lowest and highest having a difference in elevation of 700 feet. The depth of the wells varies from 600 to 3,000 feet. The logs were not ascessible to the writer, but the superintendent stated that no two holes showed the same succession of beds and that it was impossible to distinguish horizons as between wells. It is also stated that there is no clearly defined horizon at which oil occurs. As an instance, it is reported that of three wells nearly in line of strike, in beds of approximately the same amount of dip, and within a distance of but a few hundred feet, one afforded a certain oil at a depth of 1,600 feet, another a like oil at 1,200 feet, while the third, midway between the other two, was 1,900 feet deep and showed not a trace of oil. The superintendent under whose direction the wells had been drilled suggests the possibility that the oil passes from one horizon to another; this is not contrary to one or two observed occurrences, where beds impregnated with asphalt, originally petroleum, have been exposed. Of the many wells in this canyon the three south of the anticlinal axis are said not to be so productive as those on the north, yet other factors may enter into this difference besides the mere positions of the wells. The general strike of the beds in the Pico field is about N. 55°–60° W. The dip north of the axis is about 55°, south of the axis 65°, though locally on each side it is 80°.

The average production of the wells at the present time is from 12 to 25 barrels, although a few yield but 1 to 5 barrels. At the start some wells produced as high as 80 barrels, gradually dropping to the steady average maintained at the present day. The oil is green in color and its gravity 38° to 40° B. It occurs in sandstone, conglomerate, and shale, but apparently the texture of the bed is without influence on the oil. The age of this field, or the life of its oldest well, is about twenty-eight years.

DE WITT CANYON WELLS.

The wells of Dewitt Canyon are but three in number. It is reported that although they afford a slight amount of oil, the yield has never warranted operating. The well in the main canyon is located immediately south of the axis of what is apparently a secondary fold thrown off to the north from the Pico anticline, midway between the Pico field and Dewitt Canyon. The other two wells were not visited by the writer, but probably lie somewhat to the north of the axis of this fold. The formation penetrated is principally the brown shale of the Vaqueros. The strike of the axis of the branch anticline is more nearly east and west than that of the main fold to the south. The beds south of the axis dip 40°, and those north of the axis 45° to overturned. The well in the main canyon is said to have produced 1 barrel of black oil a day, of a gravity of 20° B.

The subordinate anticline on which the Dewitt wells are located may be traced eastward as far as Wiley Canyon, but no further developments have taken place along it, and its appearance is in many places that of a mere crumple rather than of a well-formed fold.

TOWSLEY CANYON WELLS.

In Towsley Canyon 6 or 7 wells have been drilled, all but 1 being near the axis of the Pico anticline. Three of the wells lie on the southern slope of the fold, the remainder on the northern slope. The strike of the beds is about N. 55° W. The northerly dip varies from 25° to 65°, the southerly from 25° to vertical and overturned. The wells near the axis of the fold yield oil, water, and gas, the 3 north of the axis producing somewhat in excess of those south of it; all, however, are small. One well, at a distance of about half a mile south of the axis, is dry. Seepages of oil occur on the axis on both sides of the canyon. The strata in the heart of the anticline are brown shale interbedded with siliceous shale and carrying hard yellow silico-calcareous beds more or less in the form of concretions. The gravity of the oil in this canyon is 26° B.

WILEY CANYON WELLS.

The wells of Wiley Canyon lie 200 or 300 feet south of the anticlinal axis. The Pacific Coast Oil Company drilled 13 wells in this canyon ranging from 600 to 1,626 feet in depth[a]. Only 3, however, were found productive. The gravity of the oil is reported to be 30° B. At the time of the writer's visit to the locality the Wiley Canyon wells were idle.

RICE CANYON WELLS.

The producing wells of Rice Canyon include 2 of the Pacific Coast Oil Company and 6 belonging to W. P. Rice. The Pacific Coast wells are in the bottom of the canyon, the Rice wells on the hill to the east. All are in brown shale bearing gray-yellow concretions of limestone. These wells lie on the south limb of the Pico anticline, comparatively near the axis. The dip on this side is 22° to 35°, on the north side 25° to 75°. The crest of the anticline over an area 100 yards wide is considerably crumpled. The Rice wells vary in depth from 825 to 1,600 feet. They yield gas, oil, and water. In No. 5, the deepest well at the time of the writer's visit, oil sands are reported at 800 and 1,550 feet. The yield of the wells is small.

Farther up Rice Canyon, one-half mile above the sharp turn from east to north, is the Newhall well, 1,500 feet deep, but without oil. The strike of the beds is here N. 65° W. and the dip 60° S. The well is only about 100 feet north of the axis of the Pico syncline, which lies parallel with the anticline at a distance of half a mile. The strata penetrated by this well are sandstone, with some shale. The horizon is considerably higher than that of the Rice wells.

EAST CANYON WELLS.

There are only a few wells in East Canyon, and but little information is available concerning them. Of the two observed by the writer, one is about 400 feet south of the axis of the Pico anticline, in heavy brown shale; the other about an equal distance north, in strata much the same. The southern well is known as the Bradshaw and is said to have yielded a small amount of black oil. The one north of the axis is reported dry.

ELSMERE FIELD.

LOCATION.

The Elsmere field comprises that portion of the Newhall district lying east of Newhall Creek and extending as far east as Los Pinetos Canyon. The productive territory is confined to the northwest end of the San Gabriel Range, which terminates at Fernando Pass and Newhall Creek.

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[a] Watts, W. L., Oil and gas yielding formations of California: Bull. California State Mining Bureau No. 19, 1900, p. 69.

GEOLOGY AND STRUCTURE.

At Fernando Pass, the low point between the Santa Susana and San Gabriel mountains, there is a break in geologic continuity. The Elsmere anticline, described below, forms another step in the en échelon development exhibited by the Torrey, Tapo, and Pico anticlines farther west. The Elsmere fold, however, is hardly more than a secondary flexure of gentle curvature on the western flank of the San Gabriel Range.

The formations involved in the Elsmere field include a vast body of granite and schist, probably of Jurassic age; chocolate-colored shale, sandstone, and minor beds of conglomerate bearing characteristic fossils of the Vaqueros formation; the Fernando (Pliocene) conglomerate, sandstone, and clay; and certain Pleistocene gravel, sand, and clay, already mentioned in the description of the Pico anticline, that occupy what appears to have been an old lake basin coincident with the present valley of the Santa Clara in the vicinity of Newhall and Saugus.

The granite and schist occupy the heart of the San Gabriel Range; the other formations, except the lake beds, encircle its west end. Although the San Gabriel Range is probably the result of faulting there is in the encircling Tertiary rocks at least one anticlinal flexure, the Elsmere. This anticline has been developed in somewhat unsymmetrical form, the axis lying well toward the southern side of the fold. (See Pl. IV, sec. M″-M-M′.) The elevation of the strata north of the axis is maintained by minor flexures, until at a distance of a mile or more the beds drop beneath the level of the lower hills and pass to the east, with a N. 70° E. strike and a dip of 25°-30° N. The syncline separating the Elsmere anticline from the Pico fold is suggested in the curves of the strata in the creek southwest of Newhall and in one or two minor crumples in the Fernando formation higher in the hills. In the Vaqueros beds on the Santa Susana side there are two folds having a general trend of N. 60°-70° W. One is the eastern terminus of the Pico anticline and the other of the syncline to the south. These folds do not appear east of the Southern Pacific Railroad, their trend carrying them at this point into the San Fernando Valley, beneath the level of which the anticline sinks. The Fernando formation, lying between the two bodies of Vaqueros east of the railroad, maintains a southwesterly to southerly dip, except immediately north of the axis of the Elsmere anticline, in proximity to the more northerly body of Vaqueros. The relations of the Fernando to the underlying strata are extremely irregular and the details of the unconformity have not been worked out. About the northern base of the San Gabriel Range, however, east of the railroad, this unconformity is readily discernible.

It is particularly marked in the varying beds upon which the Fernando rocks rest, showing that the earlier beds of this formation were deposited across the upturned edges of the Vaqueros.

The source of oil in the Elsmere anticline is in part, doubtless, from the sandstone and conglomerate immediately overlying the Vaqueros, but the numerous wells in Elsmere Canyon draw their supplies from Vaqueros strata.

OIL WELLS.

The Elsmere oil field is developed in the broad sweep of the strata about the west end of the Elsmere anticline. The companies operating, named in order from south to north, include the Enterprise, Zenith, Eureka Crude, Pearl, Santa Ana, and Pacific Coast. The Pacific Coast wells are confined chiefly to the slopes and bottom of Elsmere Canyon, although a few are ranged along the crest and western face of Elsmere Ridge. The Santa Ana Company has three wells high up on the north point of this ridge, while the wells of the other companies are ranged along a tributary of Newhall Creek, west of Elsmere Ridge, in proximity to the Los Angeles wagon road. Roughly, the wells are ranged concentrically about the anticline, the Enterprise, Pearl, and Zenith lying farthest out and to the west, the wells of Elsmere Ridge in a circle somewhat within these, and those of the Pacific Coast Oil Company in Elsmere Canyon nearest the heart of the fold. In addition to the above Nettleton & Kellerman have a group of three wells a little farther north and the New Century and Freeman & Nelson oil companies a few wells in Placerita Canyon, 5 miles east of Newhall. The well of the California Oil Company, high up on the slopes of the San Gabriel Range, is said to penetrate a few feet of still older beds of the Vaqueros and then to pass into granite.

ENTERPRISE, PEARL, AND ZENITH WELLS.

The Enterprise well and one of the Pearl Oil Company near by, both but a few feet south of the axis of the anticline, are said to be between 800 and 1,000 feet deep and to have failed to find oil. The Zenith Company, one-half mile north, has two wells which penetrate yellow sand of considerable stability; running sand, soft, blue, and bearing cobbles; blue shale or adobe, as it is called by the drillers; and at the bottom of the wells, 600 to 630 feet below the surface, other sands, together with a few "hard shells." The supply is derived from the lowermost sands of these wells, beneath about 230 to 270 feet of "adobe." The production of the wells was at first 15 barrels per day, but is now 10 barrels. The gravity of the oil is 19° B.

Two other wells of the Pearl Oil Company, adjacent to the Zenith wells, have a depth of 665 and 720 feet. The deeper is as yet unfinished. Adobe is reported in it from 370 feet down. In the other well an oil sand was encountered at 570 feet, but not until 600 feet was reached did the yield become sufficient to justify pumping. In this well sand and cobbles are reported nearly all the way down, although it is probable that in the lower portion some adobe or clay was encountered. It is almost certain that the adobe reported in this locality is but a clay body of considerable extent held in the sandstone and conglomerate. It may, however, correspond in a measure to the great body of blue clay observed in Pico Canyon between the lowest conglomerate of the Fernando formation and those next higher. Other wells were in process of drilling by these companies, but were unfinished at the time of the writer's visit.

ELSMERE RIDGE WELLS.

The depth of the wells on the crest of Elsmere Ridge (see Pl.VII, *B*) is said to be approximately 1,000 feet, but the information is somewhat indefinite. They are sunk in heavy sandstone and conglomerate which strike with the crest of the ridge, north and south, and dip 25° W. The source of the oil is probably near the base of the Fernando beds, and the production is not heavy. The gravity of the oil is reported as about 14° B.

ELSMERE CANYON WELLS.

Of the 15 wells in Elsmere Canyon, which belong to the Pacific Coast Oil Company, but little was learned. Seven were said to be productive, yielding from 7 to 75 barrels a day. They are reported to range from 400 to nearly 1,000 feet in depth. Soon after the writer's visit (1902) the company abandoned its property in this field.

NETTLETON & KELLERMAN, WELLS.

In the shallow gulch immediately north of Elsmere Canyon, perhaps a mile distant from the Elsmere wells, is a group of three wells owned by Nettleton & Kellerman. Two of these are unproductive, the other yields 10 barrels per day, deriving its supply from a depth of 1,100 feet. The gravity of the oil is 20° B. The strike of the measures is here N. 70° E. and the dip 23° N. The source of the oil is probably one of the lower members of the Fernando formation.

WELL SOUTH OF RIDGE CREST.

On the southern slope of the San Gabriel Range, about a mile east-southeast of Fernando Pass, is a well drilled near a brea deposit. It is abandoned and its history was not investigated. It is located on the outcrop of the Fernando formation, but if any considerable depth was reached it may have passed into Vaqueros beds.

PLACERITA CANYON WELLS.

Perhaps the most remarkable of all the oil fields of California is an area of insignificant size in Placerita Canyon, 5 miles east of Newhall. The oil here is almost a naphtha, and its gravity is said to be above 50°. The yield is very slight. The remarkable feature in connection with the oil is its occurrence in crystalline schist which overlies the San Gabriel granite and which is in turn overlain at no great distance from the wells by rocks that are believed to be of the Fernando formation. Oil was discovered in shafting for gold.

The schist in which the oil occurs is micaceous and granitic, conspicuously banded, and greatly contorted. It strikes approximately N. 70° W. and dips 50°–80° N. The accompanying diagram (fig. 11) indicates the position of the wells. There are six in all, the three on the north belonging to the New Century Company and those on the south to Freeman & Nelson. The New Century wells are nearer the Fernando sandstone and conglomerate, which approach within a few feet. It is said that one of these wells spouted high and that another barely flowed. The deepest well of the six is the southernmost of the Freeman & Nelson group, which attained a depth of 1,030 feet. Oil is reported in this well at 410, 613, and 682 feet. It is said to yield 5 or 6 barrels per day, with 30 or 40 barrels of water to each barrel of oil.

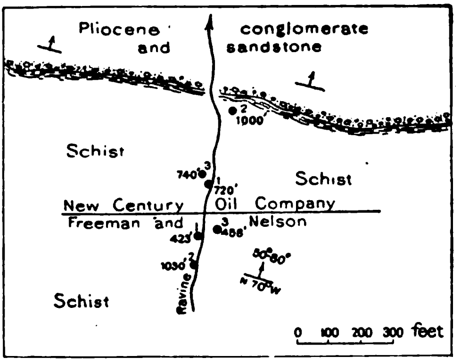

FIG. 11.—Sketch map showing location of Placerita Canyon wells, 5 miles east of Newhall. Heavy dots, wells. Figures indicate numbers and depths of wells.

In a tributary of Placerita Canyon, three-fourths of a mile east of the wells described above and in the same schist, is the Pioneer well, 1,100 feet deep. It struck oil, but the yield could not be learned. The granite lies about three-fourths of a mile south of this well.

The presence of oil under conditions similar to those that exist here is perhaps unknown in any other part of the world. It occurs from 400 to 1,000 feet beneath the surface in a steeply dipping and close-textured crystalline schist. That a reservoir, even though small, exists in such rocks must be due, it would seem, to the fracturing of the schist, the natural result of the severe contortion to which it has been subjected. If the oil originated in the schist, or rather in the sediments from which the schist was metamorphosed, it is beyond comprehension that it should have remained in them under the tremendous pressure and heat to which the strata have unquestionably been subjected. Indeed, it seems to be an impossibility that such can be the history of its development. Moreover, the gravity of the oil, between 50° and 60° B., is equally enigmatical. Even if it was originally a high-gravity oil, the lighter hydrocarbons would have been the first to be given off in the heat, pressure, and fracturing to which the rocks have been subjected, and if anything remained it should have been the asphaltic or paraffin residue. It may be that the oil is of later origin or, in any event, that it was for a time stored in another reservoir, perhaps of Vaqueros age, possibly even of Fernando age. It is possible that from such a reservoir the light oil, already from some cause separated from the heavy oil, may have found its way between the two formations and penetrated the crystalline rocks through one of their fractured zones.

THE PUENTE HILLS OIL DISTRICT, SOUTHERN CALIFORNIA.

By George Homans Eldridge.

INTRODUCTION.

In the following report it is proposed to describe briefly the geology and structure of the Puente Hills, especial attention being given to those features which appear to have a bearing on the occurrence of petroleum in the different fields of the district. The reader is referred to Mr. Arnold's report on the Los Angeles district (pp. 138–142) for information concerning the previous knowledge of the region and for a bibliography of publications relating to it.

ACKNOWLEDGMENTS.

Acknowledgments are due to the various oil companies and their managers in the different fields for assistance in various ways and for information given by them during the course of the work. Thanks are due more particularly to Mr. Fred T. Perris, manager of the Santa Fe Railway oil properties; to Mr. E. A. Bacon, of the Murphy Oil Company; to Messrs. Graham and Loftus, of the Graham-Loftus Oil Company; to Mr. R. N. Bulla, of the Central Oil Company, and to Mr. Dan Murphy, of the Brea Canyon Oil Company. Uniform courtesy has been shown by those in control of the different properties in this district, all, without an exception, furnishing any information requested.

LOCATION AND TOPOGRAPHY.

The Puente Hills, along the southern face of which has been developed one of California's most productive oil territories, are situated in the southwest corner of the State, beginning at a point about 12 miles slightly south of east of Los Angeles and extending in a general east-southeasterly direction for 22 miles to Santa Ana River. They cover an area, roughly, of about 140 square miles. The western and northern parts of the hills lie in Los Angeles County; the southeastern part is divided between San Bernardino County on the north and Orange County on the south. They are situated but 35 miles from San Pedro, the principal deep-water harbor of southern California.

The Puente Hills are the northwestern extension of the Santa Ana Mountains, from which, however, they are now separated by the deep canyon of Santa Ana River, with a fault, perhaps, as an interruption to the present continuity of structure. The general trend of the hills is west-northwest. Their highest point, 1,780 feet, is San Juan Hill, on the boundary line between San Bernardino and Orange counties. In the eastern half of the hills numerous peaks reach elevations between 1,200 and 1,400 feet, but in the western half this altitude is exceptional. The base of the hills lies about 400 feet above sea level. For 3 or 4 miles to the south an altitude of 200 or 300 feet is maintained, the southern edge of this area being defined by a low ridge that lies parallel with the hills from the region of Placentia to a point opposite Whittier. South of this the elevation drops to less than 150 feet, decreasing gradually to the sea.

The region of the Puente Hills is dry, all the streams being intermittent. The canyons are deeply cut and in places present considerable ruggedness of aspect. Nearly all are the result of erosion, although the loci of some of the erosion valleys were doubtless determined by the folding to which the strata had been subjected. Narrow, perpendicular-sided channels characterize the bottoms of many of the canyons, especially those cutting through shale. In many places, however, the higher slopes are gentle and the hill summits rounded and grassed.

GEOLOGY.

FORMATIONS.[a]

The formations involved in the geology of the Puente Hills include the Puente formation, largely sandstone and shale, of Miocene age and the equivalent of at least a part of the Modelo formation, and possibly including some of the Vaqueros; some diabase post-Puente, probably contemporaneous with similar rocks found throughout the Coast Range as far north as San Francisco; clay, sandstone, and conglomerate of the Fernando formation, largely Pliocene in age; and superficial Pleistocene deposits of sand and gravel. (See Pl. X.) The Puente formation has been divided on lithologic grounds into a lower shale, a sandstone, and an upper shale.

LOWER PUENTE SHALE.[b]

The lowest rocks exposed in the Puente Hills, which will be called the lower Puente shale or simply lower shale, embrace at least 2,000 feet of shale, in the main earthy, but with minor members of a siliceous nature, the whole gray or brown from the presence of iron and bitumen. Thin, fine-grained sandstones are interbedded with the shale from top to bottom and lenticles of gray limestone weathering yellow also occur. All in all, the formation bears close resemblance to the Monterey and certain portions of the Modelo. The only evidence of life thus far discovered consists of foraminifera and diatoms, so common in the Miocene of the Pacific coast. These occur in both shale and limestone. The shale is exposed in the heart of the hills with varying prominence; its outcrop is especially strong from Brea Canyon westward and in the southeastern portion of the hills. To judge by the sequence of beds in other parts of southern California, this shale is probably underlain by a mass of coarse sandstone.

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[a] A table giving the formations of the Santa Clara Valley, Los Angeles, and Puente Hills districts, together with their probable correlatives of the standard Tertiary formations of California, is given on p. 143.

[b] It was not the intention of the authors to apply specific names to the divisions of the Puente, but to treat them as unnamed parts of that formation.

PUENTE SANDSTONE.

Overlying the shale is a moderately coarse gray to yellow heavy-bedded sandstone, separated by minor bands of organic siliceous shale. Spherical and lenticular concretions, consisting of the same material as the mass of the rock, characterize the sandstone. The lower portion of the sandstone is more thinly bedded than the upper, and the intercalated shale is more earthy, suggesting a transition to the underlying member. This feature is especially conspicuous along lower Soquel Canyon. The thickness of the sandstone varies from perhaps less than 300 feet in the western portion of the hills to possibly over 1,000 feet in the eastern portion, where it lies in a gently undulating position, and its areal extent is very great. The sandstone is wanting in outcrop along the southern face of the hills opposite the wells of the Puente Oil Company.

UPPER PUENTE SHALE.

Overlying the Puente sandstone is a variable thickness of earthy, siliceous, and chalk-like shale, with a few beds of fine yellow ferruginous sandstone and minor quartzo-calcareous concretions. This portion of the formation will be called the upper Puente shale, or upper shale. The thickness is uncertain, but in the region of the Olinda field it appears to be considerably less than it is believed to be in the western portion of the hills. Nowhere, perhaps, is it more than 300 or 400 feet in outcrop. However, the overlying formation rests upon it unconformably, and for this reason it is impossible to estimate its full original thickness. In doubtful structural positions only has it been suspected of having a development of over 100 feet. The most important instance of this kind is on the eastern border of the Whittier field, where the crest of the hills shows the following section from north to south: In the axis, shale that is believed to be the lower division of the Puente; at the southern edge of the crest, sandstone that is identified as Puente, 200 or 300 feet in all; and on the southern face of the ridge, other shale, also of the Monterey type, bearing the fossil *Pecten pedroanus*, and succeeded across a fault plane by the next younger (Fernando) formation. The uppermost two beds have a northerly dip; the inclination of the Puente sandstone is exceedingly steep, with a dip here north and there south, and a consequent uncertainty as to which of these directions is the normal. The shale in the heart of the hills is crushed and crumpled. Were it not for this extensive crumpling and the attendant faulting the sequence given above might be regarded as normal; yet an alternative is possible, namely, that the suspected uppermost shale, with its northerly dip, occupying the southern face of the ridge adjacent to the fault line, may be instead the lower member and pass beneath the highly inclined Puente sandstone at the crest of the ridge, the two together being faulted down against the lower shale farther north, or that it may, by a sharp reversal of its dip, again return to the surface in a compressed and broken synclinal fold.

CORRELATION OF THE PUENTE FORMATION WITH THE MONTEREY.

The resemblance of both lower and upper divisions of shale, if such there be, to the Monterey, as it is known in other parts of the Coast Range, may warrant their correlation, the Puente sandstone to be regarded as an intercalated member. Yet, before finally accepting this view, it is well to recall the marked lithologic similarity of portions of the lower division of the Puente formation to certain strata in the Santa Clara Valley and elsewhere in the Coast Range that have been determined by their fossils to be lower Miocene and possibly Oligocene—lower than the Monterey. From geologic conditions to the south of the Puente Hills in the Santa Ana Range, however, the writer is inclined to consider the entire succession of beds described above as the local equivalent of the Monterey. The only fossil thus far obtained from the Puente shales is *Pecten pedroanus* Trask (see Pl. XXXVI, figs. 5 and 6), a form which is found both in the Miocene and lower Pliocene. A nearly related form, *Pecten peckhami* Gabb (Pl. XXXI, fig. 3), is a characteristic species of the Monterey (middle Miocene).

POST-PUENTE DIABASE.

A dike of diabase nearly a mile long and varying in width up to an eighth of a mile breaks through the Puente sandstone and shale along the southern slope of the hills north of the mouth of Brea Canyon. The exposed portions of the rock are so much weathered that good specimens could not be obtained. The altered material is grayish in color and shows the light-colored, lath-shaped feldspar crystals very distinctly in the specimens examined. The outcrop of this rock in the face of the ridge north of the road connecting the Puente and Brea Canyon fields has the peculiar irregular contour which enables one to distinguish it at a glance from the adjacent sedimentaries. Farther east the weathering of the diabase has stained the soil a peculiar reddish-brown color characteristic of the diabase areas throughout the Coast Range. The age of this diabase is approximately the same as that of similar diabase found in the Santa Monica Mountains in a like stratigraphic position—that is, it is post-Puente and pre-Fernando and belongs in the upper Miocene of the time scale.

FERNANDO FORMATION.

The youngest of the Tertiary formations in the Puente Hills is a succession of gray to yellow quartzose and granitic conglomerate and sandstone, together with interbedded arenaceous shale and clay, in all at least 1,500 or 2,000 feet. Occasionally a trace of eruptive débris, derived perhaps from the ranges to the north, is found with the other constituents, and locally a concretionary tendency may be observed. At one or two points, also—notably on the crest of Brea Ridge south of the Union Oil Company's wells and on the main ridge north of the wells of this company in La Habra Canyon—the formation appears to carry a few inclusions of siliceous shale and calcareous concretions. The conglomerate, sandstone, and clay are fossiliferous, the forms indicating an identity of the beds with the Fernando of the Santa Clara Valley district. A feature characteristic of this formation is the ready disintegration of its sandy shale, which under heavy traffic becomes an extremely annoying dust. This formation flanks the Puente Hills on the north, south, and west sides. It also covers a large area in the Coyote Hills, 3 miles south of La Habra Canyon, and here some exposures of its sandstone show a deep rusty or crimson color.

The following fossils, some of which are characteristic of this horizon, have been found in the Fernando beds, mostly in the vicinity of Olinda and Brea Canyon (see Pl. XXXIV to XLI):

Fossils from the Fernando beds of the Puente Hills.

[Species marked with an asterisk (*) are still living; those with a dagger (†) are supposed to be characteristic of this horizon.]

GASTEROPODA (UNIVALVES).

* Astyris (cf.) gausapata Gould.
*Bulla (cf.) punctulata A. Adams.
*Calliostoma (cf.) costatum Martyn.
†Cancellaria (sp. like San Diego well form).
*Conus (cf.) californicus Conrad.
*Crepidula (cf.) rugosa Nuttall.
*Dentalium neohexagonum Sharp and Pilsbry.
Dentalium (n. sp. like Miocene form).
*Fissuridea murina Carpenter (Pl. XL, figs. 3, 3a).
Fusus cf. barbarensis Trask.
*Nassa fossata Gould.
*Nassa perpinguis Hinds.
*Neverita recluziana Petit (Pl. XXXVIII, fig. 6).
†Priene oregonensis Redfield, var. angelensis Arnold (Pl. XL, fig. 11).
†Trochita costellata Conrad (Pl. XXXII, fig. 3).
*Trophon multicostatus Carpenter.
*Turritella cooperi Carpenter (Pl. XLI, fig. 14).

PELECYPODA (BIVALVES).

*Arca multicostata Sowerby (?) (Pl. XXXVIII, fig. 1).
Arca trilineata Conrad (Pl. XXXVIII, figs. 3, 3a, 4).
*Cardium (cf.) corbis Conrad.
*Cardium quadrigenarium Conrad, var. fernandoensis Arnold (Pl. XXXVIII, fig. 2).
*Chione (cf.) fluctifraga Sowerby.
*Leda taphria Dall (Pl. XXXVIII, fig. 5).
*Metis (cf.) alta Conrad.
*Modiolus (cf.) rectus Conrad.
†Ostrea veatchii Gabb (Pl. XXXIX, fig. 1).
†Pecten ashleyi Arnold (Pl. XXXIV, fig. 2).
†Pecten auburyi Arnold (Pl. XXXV, fig. 7).
*Pecten hastatus Sowerby.
†Pecten nutteri Arnold.
†Pecten oweni Arnold.
†Pecten wattsi Arnold (Pl. XXXV, fig. 1).
*Phacoides acutilineatus Conrad.
*Phacoides californicus Conrad.
*Phacoides nuttallii Conrad.
*Phacoides richthofeni Gabb.
Siliqua edentula Gabb.
*Solen sicarius Gould.

PLEISTOCENE.

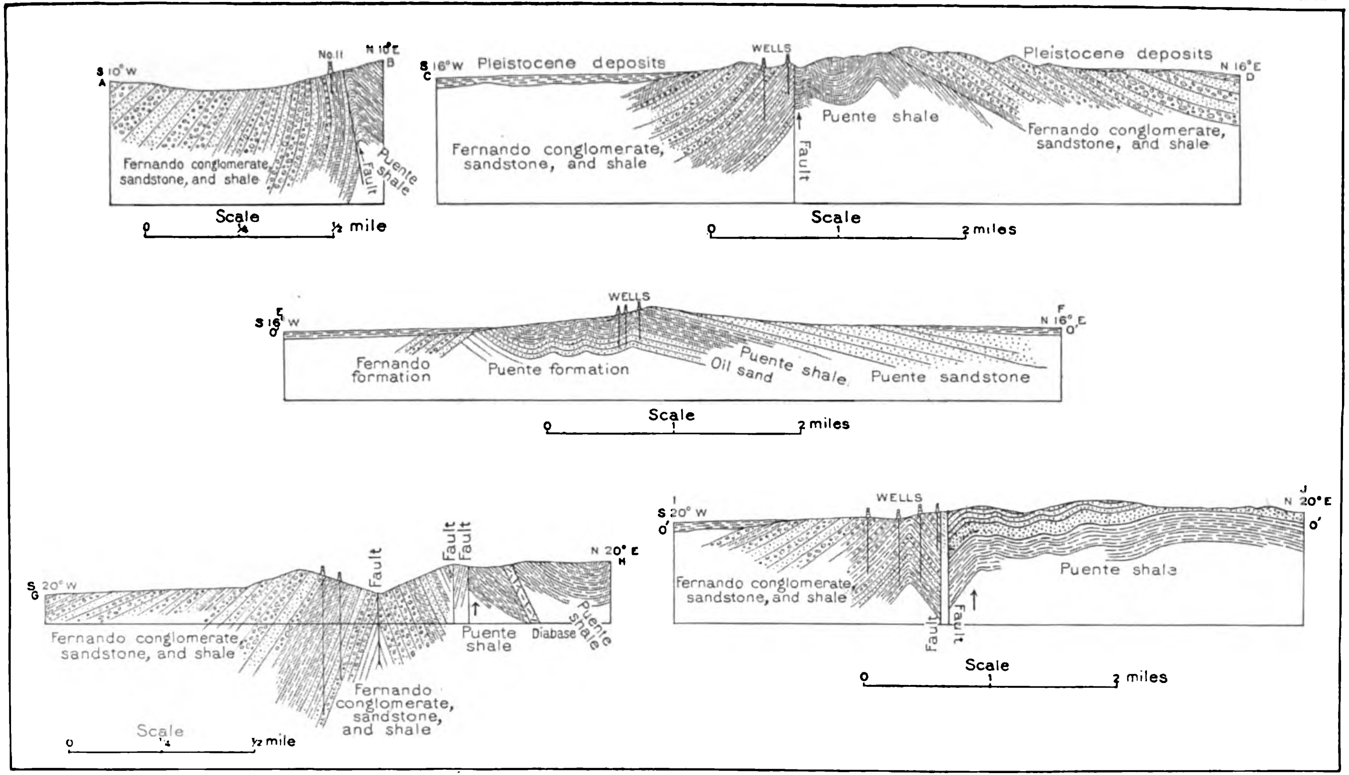
Alluvial gravel, sand, and clay of one or more periods of deposition underlie the valleys adjacent to the Puente Hills.

STRUCTURE.

GENERAL STRUCTURAL RELATIONS OF THE FIELDS.

The structure of the Puente Hills is that of an anticline, contracted in the western part, expanded in the eastern. The main axis of the flexure is not everywhere easy of recognition, owing to the prominence of some of the nearly parallel secondary folds that exist throughout the length and breadth of the hills, but the line laid down on the map (in the eastern half of the hills—the northern branch) approximately indicates the axis of the anticline. The general trend of the Puente fold is N. 65° W., varying but a few degrees in either direction. Besides the main and parallel or slightly divergent secondary folds, there are several flexures, with a trend approximately northeast and southwest. These are particularly developed on the northern slope of the main anticline in the eastern half of the hills. The most important is the broad, gentle arch occupying the region of the forks of Brea Canyon, and to this is due, in considerable degree, the areal expansion of the Puente Hills in their eastern part. The eastern rim of the hills presents several complications of strike and dip, doubtless more or less connected in structure with the Santa Ana Range to the south. (See Pl. XI.)

The south side of the Puente Hills is devoid of folds other than those secondary to and parallel with the main anticline. On this side of the hills, however, the force which produced the anticline has most severely manifested itself, the folds being sharp and numerous and the strata badly crushed. Indeed, the data at hand suggest the possibility of a fault of considerable magnitude, extending from the extreme west end of the hills nearly or quite to Santa Ana River. The amount of throw is indeterminable, but local displacements of several hundred feet are indicated by the relation of the beds. The continuity of the fault, considered as a single fracture, is not established. On the contrary, it is probable that within the zone of maximum disturbance there are a number of fractures, more or less connected, it may be, yet throughout a part of their course apparently distinct—in fact, a zone of faults instead of a single uninterrupted break. The chief evidences of faulting are the continuity of a zone of marked crumpling, the overturned and crushed condition of the beds at many points, variation in the succession of beds adjacent to the line of suspected fracture, and a divergence between trend of break and strike of strata, particularly well defined in the Whittier field. On the other hand, the line of possible fractures is at no point far distant from the contact between the Fernando and the Puente formations, and it is well known that throughout the Coast Range there is a conspicuous unconformity at this horizon. Without doubt the unconformity is



GEOLOGIC SECTIONS ACROSS THE OIL FIELDS OF PUENTE HILLS DISTRICT.

A–B, C–D, Whittier field; E–F, Puente field; G–H, La Brea Canyon field; I–J, Olinda field.

present in this field, and it is probable, too, that the younger sediments, as has been found the case with their equivalents elsewhere, were laid down upon the already upturned and partially eroded beds of the older formation. This would account for many of the irregularities noted along the length of the disturbed belt, but the broken condition of the beds on either side of the line of suspected fracture and the steeply inclined, in many places overturned, dip of the Fernando sediments in proximity thereto indicate a combined effect of faulting and unconformity for the zone in question. The conditions are almost a repetition of those in the McKittrick district, in the San Joaquin Valley, along the eastern base of the Coast Range. The oil fields of the Puente Hills have been developed in the zone of sharp crumpling and in proximity both to the trace of the possible fault and to the line of unconformity; the important wells of the McKittrick district have been drilled along the fracture and adjacent to the unconformity there existing. A guide to development has been the numerous seepages that occur along the belt of severely disturbed strata; but these have not always proved reliable indications of a large accumulation of oil.

COYOTE HILLS ANTICLINE.

The low east-west ridge known as the Coyote Hills, 3 or 4 miles south of the Puente Hills, is an anticline which flanks and is in a general way parallel with the Puente fold and was probably developed synchronously with it. The exposed strata in the west end of the Coyote Hills are the Fernando conglomerate and sandstone, but no data were obtained indicating how thick they are at this locality or at what depth the underlying Puente shale and sandstone lie. No seepages have been found in these hills, but toward their west end, 3 or 4 miles south of Whittier, is a large gas well. It is probable that oil also exists in the crest of this anticline, but at what depth and in what quantities only future development will show. Some of the most productive wells, however, are located in regions where the structure is similar to that of this ridge.

GEOLOGIC RELATIONS OF OIL-BEARING STRATA.

The distribution of the surrounding mountain masses and the position of the Puente Hills in relation thereto do not appear to have influenced the accumulation of oil. On the contrary, the significant factors appear to be the anticline, the sharply disturbed zone along its southern side, the fault that seems to be located within this zone, and the unconformity between the Fernando and the Puente formations. Finally, all the foregoing conditions would be unavailing had not the formation of petroleum taken place somewhere within the succession of beds in the close vicinity of the hills.

All the sedimentary formations in the Puente Hills, at one horizon or another, carry petroleum or its asphaltic residue. In the region developed by the Puente Oil Company, near the center of the productive belt, oil is derived from sandy strata low down in the lower division of the Puente shale. The Puente sandstone is bituminous at several points, particularly along the eastern crest of the hills, although as yet it affords no oil. The upper shale, also unproductive, nevertheless carries a small content of disseminated oil. The Fernando formation has proved extremely rich in several localities. The presence of oil at the horizons mentioned is not, however, an argument for their productiveness at all points. The factors of structure and of the original occurrence or formation of petroleum are always to be considered.

While it is evident that severe disturbance of the strata has been the chief determinant of the presence and development of the succession of oil fields along the southern face of the Puente Hills, such occurrences as that of the Chino field, on the eastern crest of the hills, 5 miles southwest of the town of Chino, are evidences of the possibilities, under right conditions, in the regions of subordinate folds. As yet, however, prospecting of the secondary and lateral anticlines has been but slight.

OIL FIELDS.

The developed oil fields of the Puente Hills include the Whittier, immediately east of Whittier; the La Habra, on La Habra ranch, 3 miles southeast of the Whittier field; the Puente, on the summit of the ridge in its most contracted portion; the Brea Canyon, 1½ miles southeast of the Puente field; the Olinda, on Olinda ranch, 7 miles northeast of Fullerton, and the Chino, about 5 miles southwest of Chino. The last-mentioned field, although within the general anticline of the Puente Hills, is independent of the other petroleum-producing areas, which lie at intervals along the belt of highly disturbed strata on the south side of the hills. (Pl. XII.)

WHITTIER FIELD.

LOCATION.

The producing territory of the Whittier oil field lies on the southern slope of the Puente Hills, beginning within a mile of the town of Whittier and extending in a S. 65° E. direction about 2½ miles.

GEOLOGY.

The field is developed along the south side of the well-defined Puente fault zone, in southward-dipping conglomerate, sandstone, and argillaceous beds of the Fernando formation, which successively abut against different members in the siliceous and other shales of

the Puente that lie with varied dip on the north of the fault. The line of producing wells trends N. 65° W., in marked divergence with the strike of the formations, which varies but little on either side of an east-west line. The wells, in other words, follow the trend of the fault rather than the strike of the beds, and in the Fernando formation the oil horizons vary with the strata that are brought into contact with the shale across the fracture plane. In the eastern portion of the field, for example, the petroleum is in beds considerably higher than in the western portion. An apparent exception to this tendency of well development to follow the fault plane exists in the long parallel strings of Murphy and Central wells that lie on either side of an east-west property line, a little north of the south line of sec. 23, T. 2 S., R. 11 W. (See Pl. XIII, *A*.) These wells closely follow the strike of the formation, with which, however, the property line, the determining factor in their location, happens to be nearly coincident.

North of the plane of separation of the Fernando and Puente formations the wells drilled in the Puente beds have been, with a few unimportant and slight exceptions, total failures. It would seem, therefore, that for this field the productive belt is in the Fernando formation adjacent to the plane of fracture or of unconformity. The width of this belt is uncertain, but is at least between a quarter and half a mile, and the oil is found at greater depths in proportion as it is distant from the line of fracture. The strata affording oil in the Whittier field are members of the Fernando formation and consist of coarse gray to yellow-brown conglomerate, heavy-bedded sandstone, and pulverulent argillaceous sand that shades locally into distinctly arenaceous clay. Here and there the clay has been hardened by the presence of lime, and in some of the sandstone also there are hard quartzo-calcareous concretions, such as have been observed in this formation at other points in the hills. Locally, also, the sandstone shows the presence of more or less dry bitumen, which imparts to the rock a brown color. The exact position of these beds in the formation as a whole is unknown, by reason of faulting, because of the unconformity which exists between the Fernando and the underlying formations, and from the fact that as yet the various divisions have not been identified and correlated by their fossil contents. Furthermore, there is an apparent variation in composition along the strike of the formation. The relative position of the beds in the eastern and western portions of the productive tract may, however, be traced with comparative precision by reference to strike lines which vary but little from east and west; a heavy conglomerate, for instance, which lies a quarter of a mile south of the Murphy and Central wells in the eastern part of the field is found fully half or three-fourths of a mile south of the Home wells in the western part. Other conglomerates that in the vicinity of the Home wells outcrop in close proximity to the fault line may be those cut at considerable depth in the Murphy and Central group.

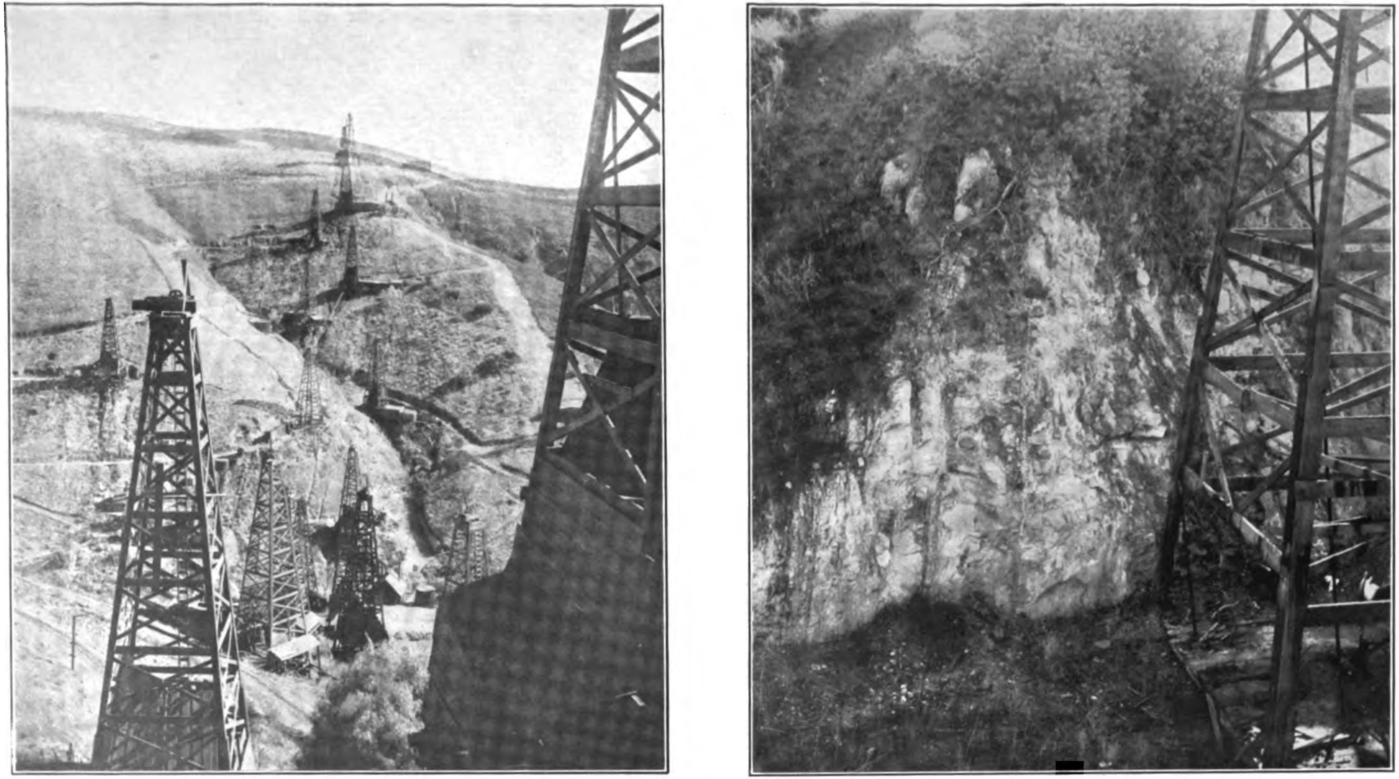
The Puente shale north of the fault line is in part siliceous, in part earthy, and in places it is brown from the presence of bitumen as well as of iron. In many of the layers may be found traces of the low organisms, foraminifera, etc., which are usually present in the Miocene formations, especially the Monterey. Limestone concretions also occur. Whether the shale outcropping adjacent to the fault belongs above the Puente sandstone or below was not positively determined. All three divisions of the formation perhaps occur at one point or another in the field, but the contorted and faulted condition of the beds requires the utmost detail of study for their successful correlation, and this the present reconnaissance did not permit. It is sufficient for the immediate purposes of this report that the Miocene shale (Puente) has been identified in faulted or unconformable contact with the oil-bearing members of the Fernando.

The number of oil-bearing horizons in the Fernando formation adjacent to the fault line and the fact that they are in contact with the bituminous shale of the Puente suggest a passage of the oil from the older formation into the various members of the younger, the fault having been not only a disturbing element affecting the positions of the strata, but also, perhaps, the means of affording a channel for the transfer of the fluid from the entire thickness of Puente shale to the several horizons of the Fernando. The fault plane, in fact, here seems to have performed in an enhanced degree the same function as the plane of unconformity between the two formations, so conspicuous an element in many of the oil fields of California. The younger formation of open, porous sandstone and conglomerate lies in contact with the bitumen-bearing shales of the Puente; in the one instance by faulting, in the other by deposition. In both instances the receptive strata of the younger formation, which happen to lie against or upon the older beds, have become impregnated with the bitumen capable of removal through wells.

That the surficial relation between the Fernando and the Puente beds is one of faulting rather than simple unconformity is argued from the irregularities of strike and dip of the various strata, but beneath the surface the unconformity which exists at the base of the upper Miocene at almost every point in the Coast Range is undoubtedly also present.

STRUCTURE.

The nature of the Puente fault zone is exhibited in a complex of fractures observable a few hundred feet north and northwest of the principal group of Central wells. It consists of two principal breaks.



A *B*

WHITTIER OIL FIELD, LOS ANGELES COUNTY.

A, Wells along property line of Central Oil Company and Murphy Oil Company, looking east; *B*, Productive well in vertical strata.

The southern, in the eastern half of the field, receives at an acute angle the axis of an anticlinal fold, which in the region of the Chandler wells is conspicuously developed in the Fernando formation to the south of all recognized fault planes. The northern break is traceable but a short distance to the east; but in alignment with it, a mile distant, is a sharp crumple in Puente strata. West of the Murphy-Central region the fault zone resulting from the union of the fractures thus described passes immediately north of the productive wells of the Fidelity, Turner, and Home companies and thence toward the west end of the hills. The block between the two faults just mentioned involves both the Fernando and Puente formations. The foregoing details derive their chief interest from their possible bearing on the occurrence and yield of petroleum in the region discussed.

Toward the west end of the Whittier field, especially in the vicinity of the Home Oil Company's wells, the Fernando beds appear to be slightly overturned. (See Pl. XI, sec. A–B.) North of the fault line, in a little ravine north of Home well No. 11, the Puente shale inclines to the north at an angle of about 25°, while immediately adjacent to the fracture it dips southward at a steep angle. The Fernando beds next to the fault are approximately perpendicular, but a little farther south, in fact as far as Home well No. 7, they dip to the north at angles varying from 75° to 90°. (See Pl. XIII, *B*.) A short distance south of well No. 7, however, the dip changes to 75° or 80° S. in rather coarse conglomerates, while the inclination of the alternating bands of sandstone and conglomerate from this latter point southward to the edge of the hills gradually becomes less.

The conditions in the vicinity of the East Whittier and Bulla wells, near the west edge of sec. 24, T. 2 S., R. 11 W., have already been referred to on page 111, under the heading "Geology." (See Pl. XI, sec. C–D.) A short distance south of the crest of the hills, in the region of the Bulla wells, the strata show sharp compression, together with a distinct break in stratigraphic continuity, Fernando conglomerate abutting against Puente shale, both dipping north. The relationship between the formations appears to mark the locus of a fault in this region. The line of division is, moreover, in the direct trend of the suspected fracture as recognized farther west. North of the fracture the Puente shale and sandstone lie in somewhat confused relationship; it is possible that a second fault parallels the main fracture, or it may be that the strata are folded into a sharply compressed syncline.

OIL WELLS.

The wells of the Whittier field draw their supply wholly from the members of the Fernando formation. They range in depth from about 800 feet close to the fault line to nearly 2,500 feet at a distance from the break, the width of the productive zone as at present developed varying from an eighth to a quarter of a mile. The sandy members of the formation, rather than those of clayey consistency, yield the petroleum, although in some instances the material is comparatively fine, while in others it is coarse and even conglomeratic. The gravity of the oil varies from 16° to 23° B., the higher grade being reported from greater depths, although, perhaps, from younger beds. It is to be remarked also that some of the shallow wells are the older and that their condition is now far from satisfactory, water having in many instances found its way into oil-bearing strata, with the consequent effects of oxygenation and the transmission of more or less impurities. The daily production of the wells is said to vary from 2 barrels in the oldest to 300 in the newest and deepest.

Among other groups of wells within what may be regarded as the confines of the Whittier field are the Chandler, a group of four wells 1 mile southeast of the Murphy and Central wells. These were about the first drilled in the Whittier field, but are now abandoned. Their location was probably determined by an oil seepage from the sandstone and conglomerate. They were, however, primitive in equipment and shallow and afforded but a light yield of heavy oil. At this point the Fernando formation lies in an anticline secondary and parallel to the main fold in the hills. The beds south of the axis dip from 45° to 70°, and those north of the axis, with steeper dip, apparently abut against the Puente fault, being in contact with the Puente shale forming the central and higher portion of the hills. This shale also pitches to the north immediately adjacent to the fracture, a position that may be either normal or overturned, the latter occurring at many places within the zone of severe crumpling along the southern face of the Puente Hills. The Chandler wells are located a little south of the axis of the secondary anticline referred to above.

One or two wells have also been drilled in the same general region as the Chandler group, but in the Puente shale north of the fracture. As in the case of other wells in this formation in the territory adjacent to the Whittier field, the results were negative. The fact, however, that the Puente shales or their included sandstone locally carry oil is evident from the field developed by the Puente Oil Company, but no law governing this relationship has been discovered. In case the oil is not originally contained in the formation, its presence is probably due to the porportion of sandy members—a factor widely variable from point to point.

At the summit of the Puente Hills, about 1½ miles north of Whittier, near the east edge of sec. 16, T. 2 S., R. 11 W., the North Whittier Oil Company has drilled two wells on the north limb of the main

Puente anticline, within a mile or two of the west end of the fold. The wells are sunk in Fernando conglomerate and sandstone, which have a regular dip. They were not a marked success and no more have been drilled in the immediate vicinity, although at depths between 900 and 1,500 feet oil-bearing strata affording a small yield were encountered. These wells are of especial interest, since they are among the first to be exploited in the younger formation on the north limb of the anticline. Faults of importance have not been observed in this locality. From surface indications the position of the North Whittier wells seems to be somewhat analogous to that of other wells in such productive fields as Coalinga, Midway, and Sunset, where petroleum occurs in formations having remarkable evenness of dip, strike, and succession.

The productive wells of the Whittier field embrace those of the Home, Turnbull Canyon, Turner, Fidelity, Strong, Central, Warner, and Murphy oil companies. Other companies have drilled at various points in the field, but thus far without success. In general, the wells immediately south of the fracture have been found productive; those to the north unproductive. (Pl. XIV, *B*.)

LA HABRA CANYON FIELD.

LOCATION.

The region of La Habra Canyon occupies the heart of the Puente Hills, midway between the Whittier and Puente fields. It has an east-west length of about 3 miles, the productive territory being near the west end.

GEOLOGY.

The geologic relations between this and the fields on either side have not been fully established, but in a broad sense the three are similar, the principal differences consisting in the details of folding, their position within the general anticline, and the strata pierced. The formations of the region include the upper and lower members of the Puente formation, together with the intervening sandstone, and the Fernando conglomerate, sandstone, and clay. Exposures of the lower shale are limited to the center of the general anticline in the eastern part of the area; the Puente sandstone outcrops in the middle, a trace of the upper shale overlying, while the Fernando formation almost closes over and around the older beds at the west end. West of this the conglomerate again gives way to outcrops of the Puente, which in the Whittier field occupies a large proportion of the ridge crest.

STRUCTURE.

The older formations in the heart of the area lie in anticlinal position, the flanks of the fold showing sharp local crumplings, with possibly a continuation of the faults that occur in the fields to the east and west. The prevailing strike is N. 70°-80° W. The position of the Puente fracture, if it be present (or of its alternative, the line of unconformity) is considerably nearer the axis of the general anticline than at points to the east, a few hundred feet only separating the two if, indeed, they are not locally coincident. As in other fields, there is here also a marked divergence between the trend of folds and the course assumed by the line of maximum disturbance. Along this line the development of oil territory has taken place. In the vicinity of the Union and New England wells, at the west end of the district, the strata show marked crumpling, with some evidence of faulting, although this is north of what appears to be the main anticline as traced from the east. The locality is one of especial confusion, owing to the compressed condition of the folds, to the proximity of the horizon of unconformity between the Fernando and older beds, and to the crushing that the rocks have undergone.

Of the several flexures present the most important appears to be that which passes directly north of the Union wells, in apparent continuation of the princpal anticline of the hills to the east. It lies considerably south of the point of greatest disturbance in the field, which is apparently in the immediate region of the New England wells. Farther west it possibly merges with the fold which appears south of the fault zone at the east end of the Whittier district. North of this fold are others, both anticlines and synclines, in one of which are the New England wells and an isolated well of the Union Oil Company. The rocks along the axis of this fold show severe crushing, with indications of considerable displacement.

At the head of the east fork of La Habra Canyon the structure again shows marked complexity. Sharp crumples, even faults, exist. The most conspicuous displacement is between the hills on either side of the road over the divide. The unconformity also is very marked, the line between the Fernando conglomerate and the siliceous shale of the Puente sweeping in a broad curve to the southern base of the hills and passing thence to the entrance to Walnut Canyon and the hills separating this from the entrance to Brea Canyon. Whether faults exist along this line is uncertain. North of the more conspicuous fracture the lower body of shale, beyond an interval of sharp minor folds, assumes a northerly dip, which is maintained by the succeeding formations to the northern limit of the hills. South of the fracture the shale, together with a small fragment of Puente sandstone, appears to lie in a sharp syncline, which is succeeded by an anticline, but there is much confusion in the details of structure, and these have not been determined. The changes in structure so frequently encountered in the Puente Hills are well exemplified in the present locality. Within a quarter to half a mile to the east the folds are less complicated, but the flexures continue to the Puente oil field, with faults, doubtless, in considerable number, but difficult of detection in the homogeneous shale.

The La Habra locality is noteworthy also in that the line of faulting and unconformity traceable westward from the Olinda and Brea Canyon fields here approaches the system of successive folds that characterizes the region of the Puente Oil Company's wells. Farther west the relations of these folds are even more intimate, and the zone of disturbance carrying them is greatly contracted.

OIL WELLS.

The only wells of the La Habra district are those of the Union and New England oil companies. They lie in two groups; the Sansinena wells, belonging to the Union Company, are situated in the gulch bottom a little south of the axis of what to the east is probably the main anticline; the other group is on the crest of the ridge, half a mile to the northwest, in highly disturbed strata close to the axis of one of the subordinate folds. The production of these wells is not large and the oil is comparatively heavy. A maximum depth of nearly 2,000 feet has been attained, although most of the wells are said to be much shallower. Oil is reported to the depth of 1,850 feet. The formations in the deeper wells embrace 300 or 400 feet of Fernando conglomerate at the top, followed by shale and sandstone below, in part, perhaps, of the Fernando, in part older.

PUENTE FIELD.

LOCATION.

The Puente oil field lies along the crest of the Puente Hills and of the general anticline forming them. It is about 1½ miles northwest of the mouth of Brea Canyon and 3 miles east-southeast of the developed territory of La Habra Canyon. The productive area is approximately 1¼ miles long by one-eighth mile wide, the length corresponding with the general strike of the beds (N. 70° W.).

GEOLOGY.

The formation underlying the region of the Puente field is the lower Puente shale, which, as shown by the well logs, is here largely interstratified with beds of fine sand varying in thickness from a few inches up to 100 feet or more; an unbroken thickness of 100 feet is, however, exceptional. Oil occurs at intervals from a depth of less than 300 feet to nearly 2,000 feet. The shale lies at the very heart of the Puente anticline and is, therefore, except in one or two places, not only the oldest body of rock exposed northwest of Santa Ana River, but the lowest formation in which oil has been found in the general region of the Puente Hills.

Flanking the shale on the north is the Puente sandstone, which is overlain by a thin body of the upper shale, and this in turn at the periphery of the hills by the Fernando conglomerate and associated beds. The dip from the crest of the ridge northward is to the north with marked regularity. South of the crest, opposite the developed territory, the shale extends to the valley level, the younger formations lying buried beneath the more recent wash. The dip on the south side of the ridge, especially in the eastern half of the field, is variable, indicating a rapid succession of synclines and anticlines, each lower as the edge of the prairie is approached. Opposite the western half of the field the folds are less pronounced and the prevailing dip on the lower slope of the hills is northward, changing to southward higher up.

Opposite the Puente oil field, for a distance of 2 or 3 miles along the southern base of the hills, the Fernando formation is wanting in outcrop, this being the only break in its continuity from a point near the Santa Ana to San Gabriel River. The ridges which usually mark the outcrop of the Fernando are also wanting, having been carried away, doubtless, by erosion at the time when the Pacific washed the base of the hills. It may be due to this that the Puente sandstone lying buried with the younger formation beneath the terrace gravels of the valley is also lacking along this same stretch of country. On the other hand, the disappearance of the Fernando and Puente sandstone may be by faulting, which is known to have disturbed the structural relations both to the east and to the west. North of the hills the strike of the Fernando and underlying formations changes from its normal direction of N. 65°–70° W. to nearly northeast. The Fernando passes from the flanks of the hills to the valley of San Jose Creek, while the Puente sandstone and the underlying shale enter into those subordinate folds of northeasterly trend which characterize the northern side of the hills from this point eastward.

STRUCTURE.

Without a detailed survey it is impossible to delineate the individual flexures of the Puente field. They are many in number, parallel with one another, of varying length and amplitude, and some are but slightly less important than the main anticline itself. There is no doubt, however, that the axis of the principal fold is here nearly coincident with the crest of the ridge, and the oil territory has been developed chiefly in proximity to this axis on either side. (See Pl. XI, sec. E–F.) From the Puente field eastward oil development has followed the line of the suspected fault and unconformity, although the main anticline has been but slightly prospected. Wells north of the line referred to, however, have been generally unsuccessful. The axis of the anticline has a gentle westerly pitch, which is maintained, except for modification by faulting, to a point beyond the New England Oil Company's wells.

Whether faulting has taken place in the immediate region of the wells is undetermined. It is suggested, however, both by the sharp crumpling which the beds have undergone and by the fact that the line of development is directly in the trend of the fault which has been recognized at the head of the east fork of La Habra Canyon. The locus of the main Puente fracture (or of its alternative, the unconformity) lies at the southern base of the hills and is traceable eastward to the Brea Canyon district and westward to the head of La Habra Canyon. The lack of confirmatory evidence to the contrary and the irregularity in the trend of the interformational line argue rather for unconformity than for faulting, although the possibility of the latter must be admitted. A feature of the field is the convergence of the axes of several folds that farther east are of considerable prominence.

OIL WELLS.

The wells of the Puente oil field are those of the Puente Oil Company, which now penetrate the lower shale of the Puente formation to a depth of nearly 2,000 feet, although for years 800 or 900 feet was the maximum. Oil is drawn from many layers of sand of varying thickness, some of the lower being especially productive and others affording but a minimum yield. The depth of 2,000 feet attained by the drill, together with the amount of erosion that must have taken place from the arch of the fold, indicates that this division of the Puente is at least 2,500 feet thick, the thickness of the entire formation being still undetermined.

The wells of the Puente Oil Company are among the oldest in California, dating back to the year 1885. Their production until recently has never been large, but has been maintained with marked constancy. Some of the newer wells have yielded 100 to 200 barrels of oil a day; but, as in the case of all other fields, this amount has decreased as the pressure has diminished and the territory has become drained. During 1905 but a few of the wells in this field were being pumped, and these only to avoid flooding. The oil is of an olive-green to black color by reflected light and varies in gravity from 22° to 35° B.

BREA CANYON FIELD.

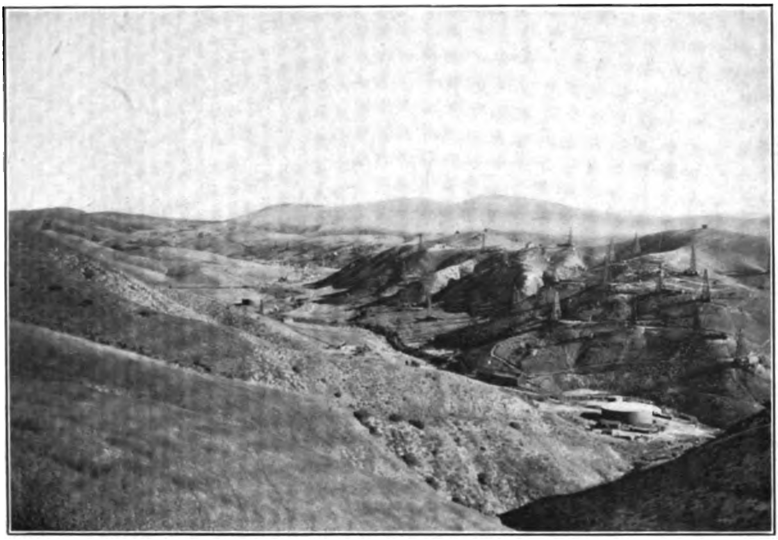
LOCATION.

Brea Canyon finds exit from the Puente hills 5 miles north-northeast of Fullerton in the vicinity of one of the most important oil districts in the territory. Below the forks the canyon assumes the trend of the main Puente anticline and lies close to the zone of maximum disturbance. At a point where the beds have been locally crushed it cuts directly through the outer terrane of the hills and passes into the valley. (See Pl. XIV, *A*.)

GEOLOGY.

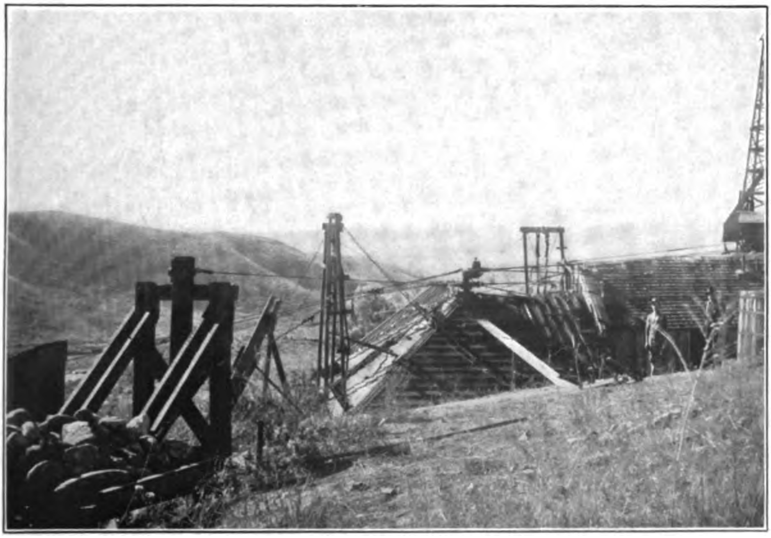
The Brea Canyon oil field is developed in the zone of highly disturbed strata along the lower canyon in a general N. 65°–70° W. direction. The formations include the Fernando conglomerate, sandstone, and arenaceous clay, the upper shale of the Puente, the Puente sandstone, here limited in area, and the lower division of the Puente, with its shale, interbedded sandstone, and lenticular masses of limestone.

The Fernando formation is well exposed along the lower portion of Brea Canyon. The higher and outer members consist of bright gray and yellow conglomerate, sandstone, and arenaceous clay. Within and lower in the series conglomerate becomes somewhat less conspicuous and traces of bitumen begin to appear. This feature is especially noticeable at the entrance to the canyon proper. Here also the sandstone, with a few pebbles, shows the concretionary structure observable elsewhere in the hills, but the formation is not on this account to be confounded with the Puente sandstone, for otherwise there are marked lithologic differences, and in addition to these the fossils of the younger beds are especially abundant and characteristic. The conglomerate of the Fernando formation enters largely into the composition of Brea Ridge, extending eastward far beyond the region of the Santa Fe wells. Westward it may be traced to its disappearance beneath the valley opposite the Puente oil field. Still lower in the series and occupying the inner or northern slope of Brea Ridge are several bands of petroliferous sandstone that display a few concretions and here and there a pebble mass and are interbedded with arenaceous clay. Two of the sandstone bands are particularly conspicuous, one well down on the north face of the ridge, the other north of the ridge near the creek channel. It is possible that these may lie at the same horizon, but that they are duplicated by faulting, the valley of the creek being coincident with a line of marked local disturbance. These beds carry fossils of lower Pliocene age. (See list, p. 107.) In the hill north of Brea Canyon there is a further succession of beds of clay, sandstone, and conglomerate, one or two of the conglomerate beds



A. LA BREA CANYON FIELD, ORANGE COUNTY.

Looking southeast.



B. CHARACTERISTIC PUMPING PLANT, WHITTIER FIELD, LOS ANGELES COUNTY.

being particularly persistent. Midway between the base and summit of the hill there is a calcareous pebbly layer, which is also fossiliferous, yielding a lower Pliocene fauna. The beds forming the lower slope north of the stream, although perhaps not a repetition of the beds south of the canyon, are unquestionably of the same formation.

A small body of limestone a few feet across, together with a little shale similar to the Puente material, was observed in the Fernando of Brea Ridge. A similar occurrence was noted near the Union wells in the La Habra district. Both are unusual and inexplicable.

Opposite the entrance to Brea Canyon the Fernando formation is succeeded on the north by shale, thin-bedded sandstone, and calcareous concretions characteristic of the lower divison of the Puente in this region. A narrow dike of diabase extending in an east-west direction for nearly a mile intrudes these Puente beds a short distance north of Brea Canyon. The shale and sandstone are directly traceable into those which occupy the heart of the general anticline 2 miles to the west, in the region of the Puente Oil Company's wells. They are overlain by the Puente sandstone in the eastern half of this field, and at the divide between Brea Canyon and the drainage of the Olinda field the upper shale in turn appears, in contact with the Fernando. In the western half of the field the sandstone and the overlying shale are wanting, having been carried beneath the surface, possibly by the Puente fault, which may here pass along the northern slope of the canyon. Notwithstanding, however, the evidences of faulting in the severe crushing which the strata have undergone, it is also possible that the unconformity admittedly existing between the Fernando and the older formations may prove to be accountable for the variation in the succession of strata, the younger members of the earlier formation having been uplifted and removed prior to the deposition of the later conglomerate and associated sediments. East of the east fork of Brea Canyon the Puente sandstone regains its prominence, and from this locality almost to the valley of the Santa Ana and the lowlands about Chino it is the most conspicuous formation of the hills.

STRUCTURE.

The structure about lower Brea Canyon is difficult to read, but from what has already been said the inference may be drawn that it is probably in direct general continuation with that both to the east and west; that is, the sharp folds, faults, and unconformity existing in the hills of the Santa Fe region extend along the northern slopes of the canyon, passing thence across the spur immediately west of its mouth to the edge of the prairie opposite the Puente oil field. The formations north of the fault line, or of the line of unconformity, show the usual variety of flexures, the shale being especially crumpled, the Puente sandstone less so. Syncline and anticline appear with a few secondary faults, parallel to the main fracture. An instance of the minor faults is to be found in the face of the ridge between the east and west forks of Brea Canyon, where Puente sandstone lies vertically against slightly undulating beds of the lower division of the Puente shale, indicating the dragging down of the younger horizon in connection with the sharp fold from which the chief displacement has been developed. Toward the crest of the hills is the main axis of the general anticline, the fold being here somewhat modified by the radiate flexure passing to the northeast between the forks of Brea Canyon.

The position assumed by the Fernando beds south of the Puente fault is of the greatest interest from a structural standpoint. The dip of the conglomerate and sandstone north of the canyon, opposite the wells of the Brea Canyon and Menges oil companies, is 50°–90° N. (See Pl. XI, sec. G–H.) There appears to be a considerable difference in the succession as well as in the composition of the beds on the two sides of the gorge, yet in the uncertainties of lithology their correlation can not be denied as possible. A doubt exists as to whether the strata immediately south of the supposed fault lie in an anticline, as in similar positions at several points along the hills, or whether the conglomerate, sandstone, and arenaceous clay have been overturned by dragging against the fracture plane in their downward displacement. At one or two points there is some evidence of the latter condition; at others there is equal evidence of an anticline; elsewhere all is confused. If the anticline exists, its axis lies near the stream channel in the lower portion of the canyon, gradually passing into the slopes of Brea Ridge toward the east, to become continuous or but slightly en échelon with that of the anticline south of the fault in the Olinda field. The line of seepages in the bottom of Brea Canyon may mark such an axis and may possibly indicate a fracture developed along the crest of the fold. The most satisfactory evidence of an anticline aside from the unconnected northerly and southerly dips along the canyon exists about the head of the small lateral gulch in which the Menges wells are situated, the Fernando formation here showing the arch of a gentle fold, which, though lying close to the Puente fault, may prove continuous with the anticline suspected as coincident with the lower portion of Brea Canyon—its westernmost extension in fact. Moreover, it may be due to the near approach of anticlinal axis and fault—perhaps to the merging of one into the other—that the exterior ridges of the hills disappear to the west, the fracture alone passing thence along the base of the ridge opposite the wells of the Puente Oil Company. On the other hand, near the suggested fault line north of the Menges and Brea Canyon oil territory there is marked confusion of the strata, and the region is not without evidence of a simple overturn adjacent to the line of displacement. If this be the case, the line of seepages along the bottom of Brea Canyon marks the line of greatest crushing in the Fernando, except directly against the fault plane. Whether anticline or overturn, however, the general conditions bearing on the occurrence of the oil must be practically the same. The composition of the Fernando is repeated in a constant succession of conglomerates, sandstones, and clays to the bottom of the series, and crushing, equal under a fold of either description, must have produced equivalent effects of texture and structure. The prime factors in the field are the Puente fault, the crushing attendant on its development, and the contact of Fernando and Puente beds.

OIL WELLS.

The companies operating in the Brea Canyon field are the Brea Canyon, the Union, and the Menges. Other companies have drilled wells, but thus far without success The wells of the Brea Canyon Oil Company occupy a small area on the northern slope of Brea Ridge adjacent to the mouth of the canyon, their number being 21. To the east, also on the northern slope of the ridge, is the area drilled by the Union Oil Company, 32 wells being distributed along the strike of the beds for a distance of 1½ miles. The Menges Oil Company's property adjoins that of the Brea Canyon Company on the west, lying just west of the mouth of Brea Canyon. This company has two wells.

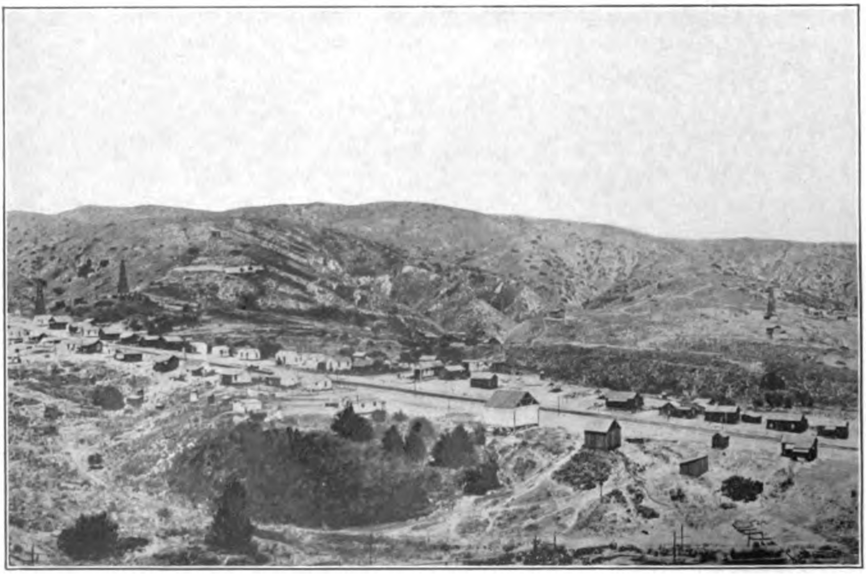
The wells of the Brea Canyon Oil Company are sunk in the conglomerate and sandstone of the Fernando formation, which strike N. 70° W. and dip about 50° S., both with considerable regularity. The strata cut are exposed, in part at least, in the northern slope of Brea Ridge and along the stream bottom, and include the bitumen-bearing sandstone referred to on a preceding page. It is impossible, however, to affirm that these horizons have furnished even a portion of the oil yielded, so at variance are the records of the wells when compared one with another and with surface exposures. It may be that owing to the crushing that has taken place adjacent to the fault and its possible extension to the region of the wells oil has filtered from the beds originally containing it into others until there has been a general diffusion of the fluid through the more porous strata along channels that for some reason have more readily permitted migration. In marked contrast, however, to the fine wells of this company on the south side of the canyon are those on the north side, where in strata far more disturbed little or no success has been attained.

The wells of the Brea Canyon Oil Company vary in depth from 600 to nearly 2,000 feet, in production from 12 to perhaps 1,000 barrels per day, in the gravity of their oil from 18° to 26° B. The heavier oil is said to come from the upper sands, the lighter from the lower. The product of the wells is run to a common tank with a resultant gravity of between 21° and 22° B.

The westerly wells of the Union Oil Company adjoin on the east those of the Brea Canyon Company, and the territory in which they are drilled, except for a slight undulation of the strike from a few degrees north of west to an equal amount north of east, is stratigraphically and structurally similar so far as surface exposures indicate. A marked difference in the productiveness of the two areas has been revealed by development, however, the many conditions in depth familiar to all students of oil occurrence probably being sufficiently variant in the two areas to cause the widely differing results obtained. It is unsafe as a general rule to predicate the success of a proposed group of wells upon that of a group already drilled, and, on the other hand, it is equally difficult to offer a tenable reason for the superior yield of one area over another, the conditions available for observation in the two being practically the same. Where there is a noticeable variation in surface conditions between two localities there is likely to be an equal variation in underground conditions, and it would not be unreasonable to expect a marked difference in the results of drilling. In illustration of this may be compared the eastern part of the Union Oil Company's tract in Brea Canyon and the western part already referred to. In the eastern part the strata show a distinct bowing to the south, and, moreover, the area is in proximity to a complex of folds that are traceable from the Olinda field. The conditions in the western part are more regular, the beds dipping rather uniformly toward the south. While in the light of experience it would be impossible to predict whether the eastern area would be more or less productive than that a mile to the west, it would be a fair inference that there would be a material difference in the yield of the two, and such a difference has been found by exploitation.

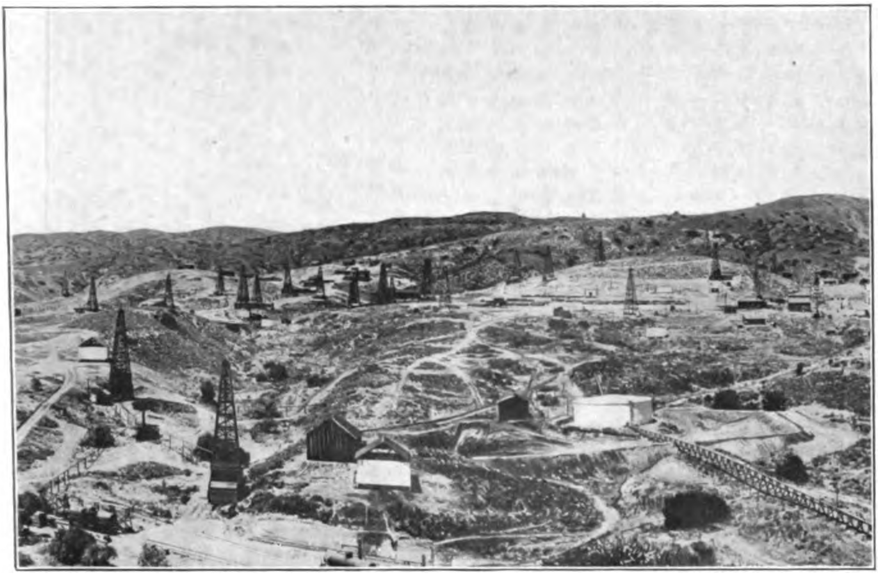
The territory of the Menges Oil Company, which adjoins that of the Brea Canyon Company on the west, is structurally at variance with both productive tracts described above and has so far yielded smaller wells. The general horizon at which oil is obtained by the Menges and the Brea Canyon companies is the same, but between the two tracts, strongly developed at the sharp bend in the canyon, is a compound flexure involving the oil-bearing strata, in part at least, of both properties. The flexure is as local as it is sharp, and disappears within a short distance of the stream. In the Menges tract, however, the strata are more disturbed than in that of the Brea Canyon Company, showing local and abrupt variations in both strike and dip, at one or two points with distinct overturns having a northerly dip.

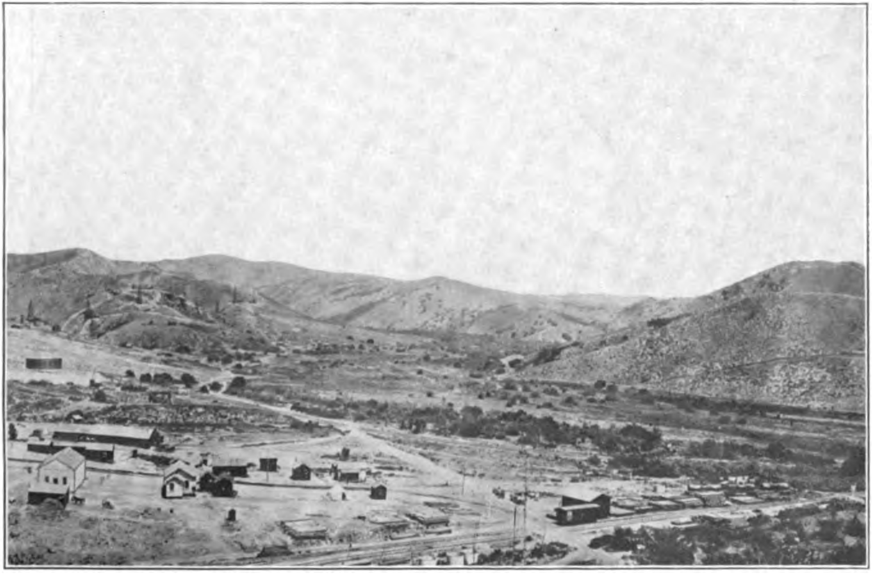
The foregoing discussion has been carried to considerable length at this point because of the typical example afforded by the Brea Can-



PANORAMA OF C

From Olinda Ridge, Orange





OLINDA OIL FIELD.

County, looking west to east.

yon field of the varying conditions attendant on the occurrence of petroleum within a comparatively small area. This field illustrates, also, the impossibility of offering a definite opinion regarding the probable productiveness of a particular territory, an opinion frequently asked of the geologist by all interested in the petroleum industry.

OLINDA FIELD.

LOCATION.

The Olinda oil field lies 6 miles northeast of Fullerton, just within the southern edge of the Puente Hills, near the entrance to Soquel Canyon. It is connected with the main line of the Atchison, Topeka and Santa Fe Railway by a branch from Richfields, 4 miles south. As developed, the field extends along the strike of the measures, N. 65°–70° W., about a mile and a half, the breath of the oil-bearing zone varying from one-eighth to one-third of a mile. The field is supplied with water from wells a mile or two out in the valley. In the immediate vicinity of the productive area the principal features of topography include the main mass of hills, an exterior ridge which borders Telegraph Canyon on the south and extends for a mile beyond the entrance to Soquel Canyon, and an inner valley separating the hills from the exterior ridge. Development has taken place in this valley and on the lower slope of the main mass of the hills to the north. (See Pl. XV.)

GEOLOGY.

The formations involved in the Olinda field embrace the upper and lower Puente shales, the Puente sandstone, and the Fernando conglomerate, sandstone, and arenaceous clay. The lower Puente shale, the homologue of that in the Puente oil field, is exposed principally to the east of the developed territory, along Soquel and Carbonne canyons, entering but slightly into the higher portions of the ridges. The Puente sandstone is confined entirely to the main body of the hills, extending north and east from the edge of the field for many miles and forming the cap rock on all the higher portions as far as the Chino divide. The upper shale is not well developed, and it is questionable whether it is present at some places in more than a trace. The Fernando formation constitutes the mass of the ridge south of Telegraph Canyon, the point of the ridge between Telegraph and Soquel Canyons, the hills west of the entrance to Soquel Canyon, and the low bench lands between the latter and Brea Ridge, at the west end of the field. It finally enters Brea Ridge and passes westward to the Brea Canyon field. It also underlies a considerable portion of the interior valley. These formations all extend to the region of Santa Ana River.

STRUCTURE.

The Olinda oil fields lie on the southern limb of the general anticline of the Puente Hills. The prevailing dip of the strata is, therefore, to the southwest, but an opposite dip is encountered at many places by reason of subordinate folds developed on the flanks of the principal flexure. The axis of the main fold, which trends N. 65°–70° W., lies somewhat less than a mile north of the oil belt, those of the lesser folds traversing the intervening space.

The northern edge of the oil belt, which is closely coincident with the base of the main body of the hills, is the locus of an extremely sharp fold that has many of the attendant features of a fault. In immediate proximity to it, also, is a trace of the contact between the Fernando and older formations, but whether this is a plane of faulting or of unconformity it is difficult to say. Perhaps the conditions are the combined results of the two, for the evidence for each at one point or another seems almost conclusive. The formations which are in contact are the Puente sandstone and the shales beneath and above on the north, and the conglomerate, sandstone, and clay of the Fernando formation on the south.

The zone of disturbed strata is traceable westward directly into Brea Canyon and eastward across the point of the ridge between Soquel and Telegraph canyons well into the hills south of the latter. It is marked in numerous places by heavy seepages of oil, which, however, appear to be from the Fernando rather than from the older beds. Beyond Telegraph Canyon the examination was not conducted in detail, but it is a significant fact that in the vicinity of Santa Ana Canyon, directly in the line of maximum crushing in the Olinda field, is another area of disturbance found by Mr. Homer Hamlin in a hurried inspection of the geologic conditions there existing.

The evidence for a fault in the Olinda field consists in an irregular succession of beds, a zone of crushed strata for 200 or 300 feet on either side of the interformational line, sharp flexures with local downward curve of the Puente beds on the north of the suggested plane of displacement and upward bend of the Fernando on the south, and the high inclination of both formations. These features also attest to the development of the fracture subsequent to the deposition of the Fernando, although prior to this period faulting might have taken place along a line practically coincident with the later displacement. In fact, there is ample proof in the hills area that the rocks of the Puente had been considerably folded before the Fernando formation was laid down upon them, and it may be that they were faulted as well.

The suggestion of unconformity is borne out by divergence in dip and strike and by the presence in the Fernando of materials unmistakably derived from the older beds. It is, moreover, in harmony with observations throughout a large portion of the Coast Range. The fact that in the Olinda field, therefore, the Fernando formation lies at one point against the lower shale of the Puente formation, at another against the upper shale, and at still another in contact with the Puente sandstone, may be attributed to unconformity, to faulting, or to both. As already mentioned, the writer inclines to the belief that both of these causes have contributed their part in the development of the existing conditions.

The principal features of structure in the Olinda field will now be taken up in somewhat greater detail. In the eastern third of the field, from the vicinity of the gulch containing Santa Fe wells Nos. 21, 32, 36, and 38, eastward to the Columbia ground and Soquel and Telegraph canyons, there appear to be two divergent lines of structure, the southern line marking the trace of the main fault, or of its alternative plane of unconformity between the Fernando and the older beds, maintaining the general trend of N. 65°—70° W., and passing across the lower portion of Telegraph Canyon; the northern, a line of severe crushing, extending more directly eastward or even a little north of east and following the gorge of Soquel Canyon. The northern line is confined wholly to the Puente formation. The combined effect of faulting and folding, together with the divergence in strike noted, has brought to the surface, north of the divisional line between Puente and Fernando, beds gradually lower in horizon toward the east, the prevailing dip being 25°-60° N. As the divergence increases additional crumples, some of them extremely sharp, appear in the Puente beds.

Immediately north of the northern of the two divergent lines referred to above and close to the northern line of wells is located the axis of the general syncline that is so persistent and conspicuous a feature along the northern border of the Olinda field. Its trend is N. 65° W. and it is especially prominent in the Puente sandstone. This syncline is of especial interest near the center of sec. 9, where are clustered several wells of the Santa Fe, Fullerton Consolidated, and Columbia (Puente lease No. 1) oil companies. At this point there is considerable uncertainty regarding the stratigraphic horizon, both from the crumpled condition of the beds and from the lack of distinguishing characteristics. The Puente sandstone appears a short distance north of the wells, dipping to the south, but about the wells the strata dip northward and have more the nature of arenaceous, granular, and muddy shale, with traces of the siliceous variety, in one instance faintly organic. On the whole the formation bears considerable resemblance to that underlying the Puente sandstone along the lower slopes of Soquel Canyon east of the Columbia wells (lease No. 1), and yet it is not unlike certain members of the Fernando. The writer is inclined to place the beds in the Puente and to regard the area as lying within a zone of especial disturbance that is manifest along both the main fracture and its northern branch, in all probability in an interfault block. The syncline is traceable in strike from north of east through north to north of west, and in a dip correspondingly variable from north to west and then to south around the east end of the trough, this being especially manifest in the heavier sandstones at the point occupied by the Fullerton wells, which lie close to the synclinal axis or a short distance off on its southern limb. Evidences of the syncline continue eastward to the bottoms of Soquel Creek in a constant repetition of the structural features of the Columbia ground (lease No. 1), a westerly dip along the axial line locally as high as 45° being especially noticeable. Beyond Soquel Canyon the identity of the syncline is lost.

Most of the Columbia wells (lease No. 1) are located on the south side of the synclinal trough; some, however, are close to the axis, while two or three of excellent yield appear to be in strata that dip to the south or are intensely crushed. One of the deeper wells in which, up to the time of the investigation, no oil had been found penetrates at the collar the organic shale of the Puente. The others, which start in heavy sandstone, probably of the Puente formation, are highly productive.

The easterly wells of the Santa Fe and those of the Fullerton and Columbia oil companies appear thus to have been drilled in the Puente formation, in ground whose structure is somewhat uncertain. Most of them lie a little south of the line of maximum crumpling. It may be inferred, therefore, that the horizon of their oils is approximately that of the oils of the Puente Oil Company's wells 5 miles farther west. Moreover, the logs of the wells indicate the presence in depth of shale similar to that of the Puente oil field, whereas in other portions of the Sante Fe area the strata are of the more open and porous nature characteristic of the Fernando. This similarity of strata penetrated in the Puente field and the east end of the Olinda field accounts for the similarity of the oils of the two localities. The gravity varies between 23° and 35° B., the oil of the Olinda field being somewhat the lighter.

Typical Puente shale with steep dip is exposed a few feet east of the Columbia camp (lease No. 1), several hundred feet south of the eastern wells of this company. The outcrop is in line with others of the same nature up Soquel Canyon, and it is probably continuous with them, the Fernando having here crossed to Telegraph Canyon. Loose shale fragments are also found over a considerable area in the same general region south of the wells.

Along the middle portion of the field, in the eastern half of the Graham-Loftus tract, the strata occupying the face of the hills north of the wells but south of the syncline, extending from the region described in the foregoing paragraph, include yellow and gray concretionary sandstone of the Puente type, with the associated siliceous shale and a succession of sandstone and arenaceous shale, also yellow and gray but apparently devoid of concretions and of the minor organic forms that characterize the Puente. There appear to be two formations in juxtaposition—one undoubtedly Puente, the other closely resembling the Fernando. Their relations suggest the locus of the Puente fault, a view strengthened by the sharp disturbance affecting the strata in the adjacent gulches. The strike of both formations is the same, about N. 70° W. The fault plane, on the whole, is believed to pass a short distance south of the northernmost of the Graham-Loftus wells, No. 17, but north of the others in this vicinity. With the exception mentioned, therefore, all the wells in this part of the field have apparently been drilled in the Fernando formation, and this view is borne out by the fact that conglomerate is encountered at various depths in the wells of both the Santa Fe and the Graham-Loftus companies. The position of these wells is believed to be on the northern limb of the subordinate anticline south of the fault.

Outcrops of conglomerate and siliceous shale about 125 feet northwest of the Santa Fe No. 12 well may be regarded as locating the position of the main Puente fracture for this part of the field. The strike of the conglomerate ranges from N. 85° W. to east and west; the dip 35°–40° N. The shale, as usual, shows large crumples for a considerable distance from the fault. The westernmost well of the Santa Fe Company, No. 37, is close to the line of rupture, possibly a little to the north of it.

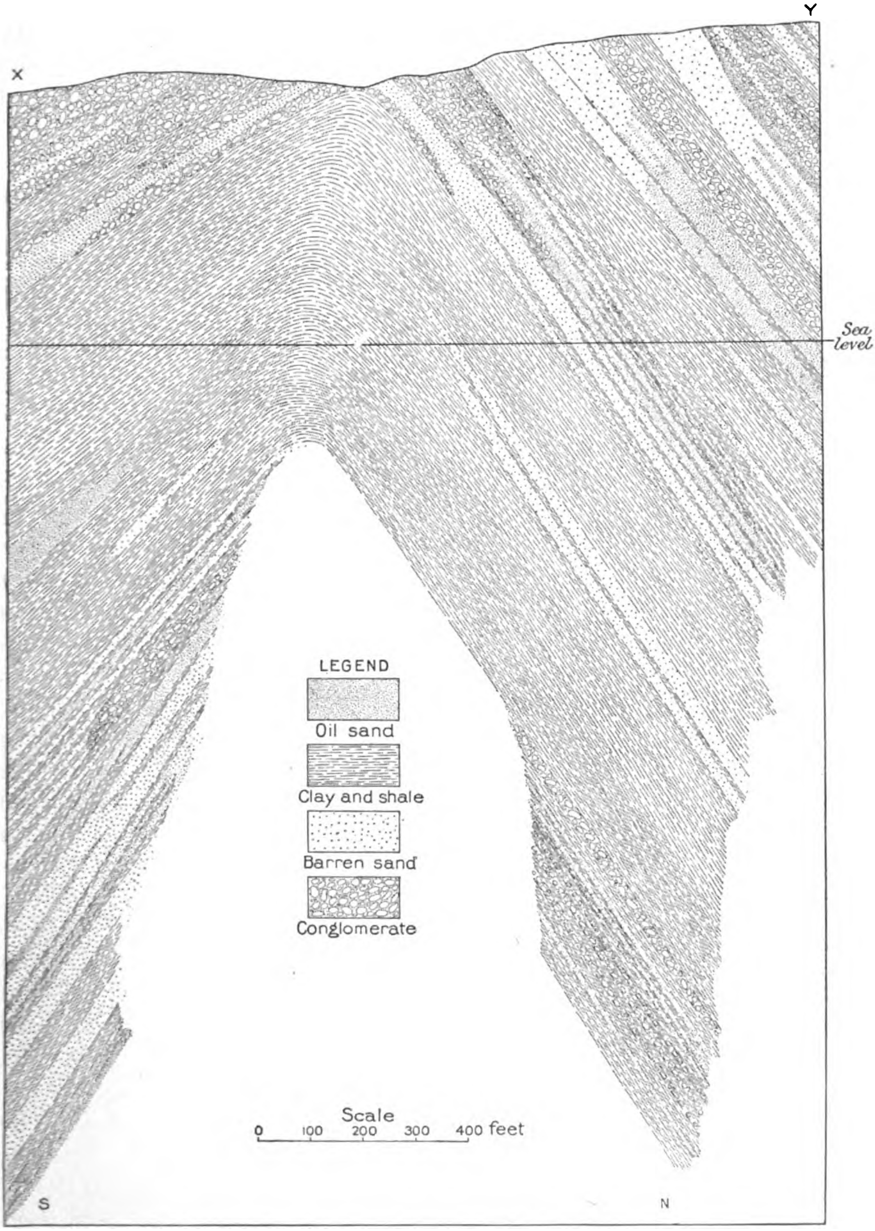
The structure just described continues with some variation, not only to the west end of the field, but into Brea Canyon and the territory north and south. The locus of the fault as it crosses the divide between the Olinda and Brea valleys is obscure, but it is not far from the point of least elevation. North of this point heavy beds of Puente sandstone lie in vertical or overturned position, bending, however, to a southerly dip of 20° or less as they pass to the summits of the hills above. South of the divide and for a mile or more along the southern slope of the ridge north of Brea Canyon the siliceous shale of the Puente outcrops. Although this shale is in natural sequence with the Puente sandstone on the north, it is believed that, on account of irregularities in adjacent areas, the two beds are separated by the Puente fault, or at least by a subordinate fracture. In Brea Canyon the syncline that in the Olinda field lies immediately north of the fault disappears, although other flexures in considerable number, among them a syncline of some importance, may be observed along the slope of the hills to the west.

In the region of the Santa Fe wells the details of structure for the area along the interior valley underlain by the Fernando conglomerate, in which much of the development has taken place, are somewhat obscure. In a general way, however, it is evident that east of the western group of Columbia wells (lease No. 2) the strata are deflected from their general strike of N. 65°-70° W. to N. 45° W. in the vicinity of the southwestern Santa Fe wells, thence bending to S. 70° E. and passing onward into the ridge south of Telegraph Canyon. A trace of a similar and concentric deflection, with marked local folds, exists also in the rocks of the older formation northeast of the Fernando area, in the hill slopes north of the Santa Fe village, and the flat to the east. The explanation may be that compression took place after faulting, affecting the strata in a like manner on both sides of the general fracture. Still, this occurrence may be a coincidence rather than one of direct relationship in the movements of the beds.

Again, the Fernando formation, though of comparatively steep southerly dip in the exterior ridges of the field, assumes a much lower angle of inclination farther north in the interior valley region, with an actual northerly dip, as evidenced by the logs of the wells of the Graham-Loftus and Columbia oil companies, near the line of the fault or of maximum folds. (See Pl. XI, sec. I-J, and Pl. XVI.) In other words, there is apparently, through at least the western half of Olinda Valley, an anticline whose axis coincides with that of the valley, trending about N. 65° W.

The anticline is clearly traceable in the eastern face of Brea Ridge, the axis passing through the southern group of wells of the Columbia Oil Company (lease No. 2), or probably a short distance to the south of all these wells. Evidences of the fold also appear in the structural lines that cross the crest of the ridge diagonally in Union ground, a mile west of the Columbia wells (lease No. 2), and in some of the gulches that cut the northern face of the ridge in the same vicinity. The strikes and dips vary according to the position of the beds in the fold. It is possible that the anticline continues westward to the Brea Canyon field, being identical with the fold suggested along the line of seepages in the bottom of the valley. Some irregularity is displayed in the disposition of the strata along the eastern third of Brea Ridge, the Fernando formation being confined to the southern limb of the anticline, though crossing to the north of the axis in the region of the Columbia wells (lease No. 2), and possibly farther west, in the ridge between the forks of Brea Canyon.

How far to the east the anticline extends is undetermined. It does not appear in the Fernando at the point of the ridge between Soquel and Telegraph canyons, although the Puente beds here have the opposite or northerly dip and half a mile up Telegraph Canyon show distinct evidences of a fold. It may be that the anticline continues



DETAILED GEOLOGIC SECTION THROUGH OLINDA OIL FIELD.

through to this point, the Fernando, however, no longer bending over the crown of the arch.

The direction which the eastward extension of the Olinda field may take is somewhat problematic. The development in Columbia ground (lease No. 1) follows the northern fracture, or at least the line of excessive disturbance passing up Soquel Canyon to the entrance of Carbonne Canyon; the surface conditions prevailing in the western half of the productive territory, however, continue across to Telegraph Canyon, except that the Fernando conglomerate is in contact with lower members of the Puente than to the west. Apparently the beds are somewhat transitional in their nature, gray micaceous sandstone and shale lying beneath the Puente sandstone, the precise horizon varying from point to point. The structure of the lower beds is very complicated. In the northern face of the ridge between Telegraph and Soquel canyons the rather heavy gray and yellow gritty sandstone dips to the north, while the associated brown argillaceous shale, only 150 feet distant, has a southward inclination. The strike of both is N. 65° E. In the southern face of the ridge the principal dip of the older rocks is 45°–80° N., although half a mile up Telegraph Canyon the beds of the same character begin to show a southerly dip, which is maintained well into the hills to the south. The conglomerate south of these beds strikes N. 65° W., nearly parallel with the axis of the anticline referred to above; it dips 80°–45° S., according to the distance from the fault line. It rests upon older beds that dip in some places to the north, in others to the south, the northward-dipping rocks lying near the mouth of Telegraph Canyon. The similarity of the conditions in Telegraph Canyon and in the western half of the Olinda field is thus obvious, and while there are slight differences it would, nevertheless, seem reasonable, from surface conditions, to expect equal chances for obtaining petroleum along the line of the fault or unconformity in the two localities. However, wells at some distance from this line, in the Fernando beds on the ridge south of the interior valley, have not yet proved successful.

In the discussion of the relations of Fernando to Puente in the region of Telegraph Canyon the question of faulting or unconformity arises with the same force as elsewhere. The conditions are explicable on the basis of an unconformity, the upheaval and erosion of the older rocks prior to the deposition of the Fernando being presupposed; they may also be explained by faulting, or they may be due to the two causes combined.

OIL WELLS.

The oil wells of the Olinda field number over 100, and except a few, chiefly along the outer ridge, all have been of wonderful productiveness, yields of 700 to 1,000 barrels of oil per day having been reached. The maximum depth attained is 3,000 feet. The wells are ranged along two lines, the northern group following the zone of greatest disturbance, together with the fault, and the southern following the land line which separates the properties of the Santa Fe and Fullerton Consolidated oil companies and having no connection whatever with the structure.

The oils of the Olinda field vary in gravity from 12° to 35° B., the heaviest being found at the west end of the field in members of the Fernando, those of 18° to 20° B. in the southwestern part, also in the Fernando, and those between 23° and 35° B. in the eastern half of the productive area in various horizons of the Puente.

CHINO FIELD.

The Chino oil field occupies a small area on the crest of the divide between Soquel Canyon and the Chino Valley, 5 miles southwest of the town of Chino. It is located on what appears to be one of the northeast-southwest flexures that radiate from the main Puente anticline. The wells, four in number, are drilled in the axis of the flexure and on either side. They pierce the Puente sandstone and underlying shale, but the details of their logs were unavailable at the time of the writer's visit. Aside from their commercial value, they are of especial interest as suggesting the possibilities of at least some of the subordinate folds in the hills.

CONCLUSIONS CONCERNING FUTURE DEVELOPMENT.

Whether petroleum will be obtained north of the line of maximum disturbance in the Puente fault zone, in rocks adjacent thereto, is questionable. Thus far wells in this position have been unsuccessful. A reservoir of coarse sand or other open-textured rock is filled with oil at the expense of the finer strata in which it may prove to have been but temporarily stored, or in some of which it may have even originated. Under conditions such as have been described, it may be inferred that in the region of the fault, along the southern face of the Puente Hills, the oil has been drawn from the beds north of the fracture zone into the more crushed and hence more open and porous strata of the same age south of it, and also into the still more receptive reservoir of coarse sediments presented in the Fernando formation. How great an area north of the fault may have thus been drained it is impossible to say.

An argument in favor of productiveness of the Puente formation away from the zone of faults is presented by the Puente Oil Company's wells, which are drilled in an anticline in the lower division of this formation. Similar evidence is also offered by the wells of the Chino Oil Company, which penetrate the Puente, including the sandstone, on a fold subordinate to the main Puente anticline, yet not far from its axis. That the lower Puente shale in these hills is generally oil bearing in some degree is recognized, that the Puente sandstone is also impregnated with bitumen is evident, but that the shale and the associated sandstone are everywhere impregnated to such an extent as to render them of economic value, under structural conditions that would be regarded as favorable, is improbable.

PETROLEUM OF THE PUENTE HILLS DISTRICT.[a]

YIELD AND GRAVITY OF OIL IN DIFFERENT FIELDS.

The yield of the individual productive wells in the Puente Hills varies from 1 to over 1,000 barrels per day, those in the Puente field giving the lowest averages and those in the Brea Canyon field the highest. The wells of the Whittier field produce oil varying from 14° to 24° B., the yield of the individual wells running from 2 or 3 barrels to nearly 175 barrels per day (in one well), although it is said that one or two wells went as high as 400 barrels at the start. The gravity of the Puente field oil runs from 28° to 34° B., but the average yield of the wells is lower than in any other part of the district, and none of the wells have gone much over 100 barrels per day, even in their prime. In contrast with the low production and high-grade oil of the Puente field is the high production and medium-gravity oil of the adjacent Brea Canyon field. The gravity here ranges from 18° to 26° B., while some of the wells yield as high as 1,000 barrels per day. Several flowing wells have been struck in this territory, one at least, it is said, gushing with a pressure of more than 250 pounds to the square inch. The Olinda field furnishes both high and low grade oil, the high grade, with a maximum of 35° B., coming from wells in the northeastern part of the field yielding from 2 or 3 to 150 barrels per day, and the low grade, with a range of 18° to 20° B., coming from wells in the west end. Six "gushers" have been developed at Olinda, one of which is said to have flowed at the rate of 20,000 barrels per day for a short time. One of the flowing wells on the Santa Fe property is now (October, 1905) flowing under a pressure of 100 pounds to the square inch.

FACTORS IN YIELD OF WELLS.

The factors governing the yield of oil wells, aside from the natural conditions—porosity of rock, pressure, etc.—are usually those connected with the manipulation of the wells, such as size of casing, loss of tools, caving in of casing, or accidents of one kind or another. Sometimes, however, the condition of the oil market has a most potent influence on the production by causing the partial or total shutting off of the wells; this has been the cause of a decline in the production of several groups in the Puente Hills district during 1905.

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[a] For a discussion of the physical and chemical properties of the oil of the Puente Hills, see pp. 210-217.

The yield of most wells becomes less with the lapse of time. This decline is generally more marked during the first few months of the well's life than later, when the conditions governing the flow appear to become more stable. Pl. XVII, giving the average daily yield by months of a group of wells in the Puente Hills district, illustrates graphically the common variations in the yield. The minor fluctuations in the curves are usually traceable to the sanding up or cleaning out of the wells or to other local causes.

ASSOCIATED HYDROCARBONS.

Brea and gas are the only hydrocarbons associated with the oil in the formations of the Puente Hills district. Brea (sand or soil impregnated with oil from seepages, the volatile substances having evaporated) is found in all of the fields. The largest deposits in the district are in Brea Canyon, on the south slope of which are considerable areas covered by the material. No practical use has been made of it except locally for road dressing.

Nearly all the wells in the territory under discussion yield more or less gas, especially in the earlier stages of their existence. In some localities the gas contains a considerable percentage of hydrogen sulphide, to judge by the odor encountered in the vicinity of certain wells; in others the gas is of such a quality as to be used profitably both in the generation of power by gas engines and for domestic purposes. Among the companies making use of the gas derived from their wells are the Santa Fe, in the Olinda field, and the Murphy, in the Whittier field. The Santa Fe Company is said to use gas entirely for all purposes requiring the generation of heat and light on its property. Some years ago a well yielding gas under strong pressure was struck south of Whittier, in the western extension of the Coyote Hills anticline. This well never furnished any oil, and as the gas gave out the hole was abandoned.

STORAGE AND TRANSPORTATION.

With the exception of the oil in the Olinda field, much of which is stored in open earthen reservoirs, most of the oil of the Puente Hills district is stored in circular metal tanks. These tanks are usually covered, and vary in capacity from 5-barrel settling tanks to storage tanks holding about 55,000 barrels. The tankage of the Whittier field is something over 200,000 barrels; that of the Puente field, including the Chino refinery, over 100,000 barrels; that of Brea Canyon approximately 85,000 barrels, and that of the Olinda field possibly 200,000 barrels. In addition to this, the Union Oil Company has a storage capacity of about 150,000 barrels at Norwalk, the center of its pipe-line system, and of 37,500 barrels at San Pedro, its shipping point by boat.

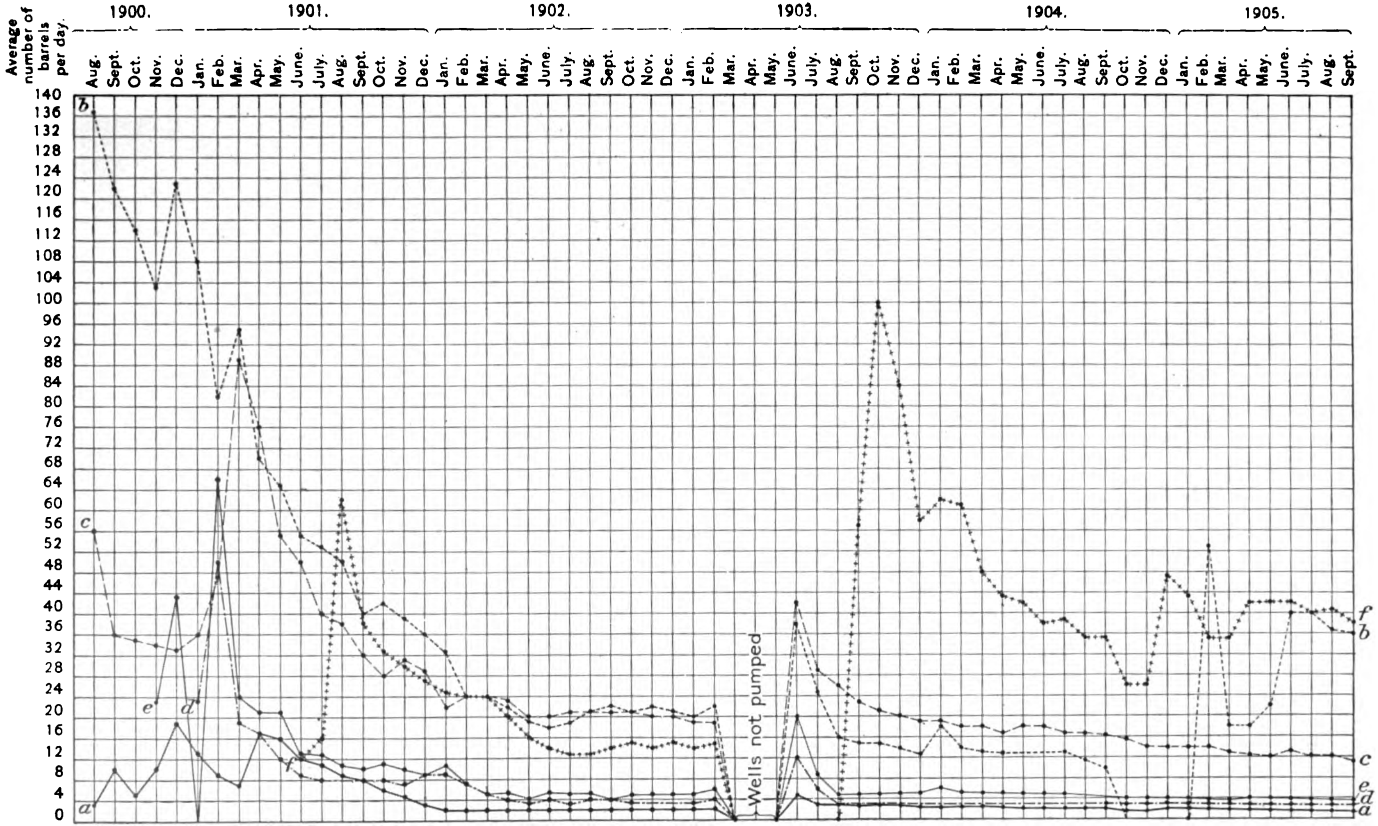

CHART OF VARIATIONS IN AVERAGE DAILY YIELD OF SIX WELLS IN THE PUENTE (MIOCENE) SHALE AND SANDSTONE TERRITORY (REGION OF LIGHT, OR 32° TO 34° OIL), PUENTE HILLS OIL DISTRICT, CALIFORNIA.

The Union Oil Company owns all the longer pipe lines in the district, with the exception of the 13-mile 3-inch line of the Puente Oil Company from its property to its refinery in Chino and the 3-inch line of the Murphy and 4-inch line of the Central oil companies from their wells in the Whittier field to Los Nietos, 3 miles farther west. The Union lines comprise 17 miles of 5-inch pipe from San Pedro to Norwalk; 15 miles of 4-inch (some 5-inch also) from Norwalk to Los Angeles; 12 miles of 4-inch from Norwalk to Brea Canyon; 3 miles of 4-inch from Brea Canyon to Olinda, and 4 miles of 4-inch from Whittier to a junction with the Norwalk-Brea Canyon line.

The oil is shipped from Olinda and Los Nietos over the Atchison, Topeka and Santa Fe Railway, and the Southern Pacific Company has connections at Whittier and Los Nietos and also at the Puente Company's refinery at Chino. The Union Oil Company is the only one shipping oil by water from this district, its loading point being San Pedro, which, as already mentioned, is connected by pipe line with Norwalk and thence with all the fields of the Puente Hills.

UTILIZATION OF THE OIL.

Much the larger part of the oil produced in the Puente Hills is used in southern California. Some of the product, however, is exported and shipments have been made to Alaska, Washington, Oregon, Arizona, New Mexico, the Hawaiian Islands, and even to Chile. In Alaska the oil is used principally for the development of power for mining purposes, while in Washington it is coming into direct competition with the local coal, which it is supplanting for purposes of gas production and as a fuel. The chief uses for oil in Arizona and New Mexico at present are in connection with mining. In the Hawaiian Islands the oil is used principally for fuel in the refining of sugar and for the development of power needed in the irrigation systems on the great plantations. In southern California it is used for the following purposes, named in the order of the amount consumed: Fuel, illuminants, the direct development of power in gas engines, oiling roads, and lubricants.

A new use for oil that has been developed during the past five years is for the purpose of road dressing. California is virtually without rain for two-thirds of the year, and as a result the subject of dusty highways is one of paramount importance. It has been found by experiment that the heavy oils not only settle the dust but, if properly applied to the road, produce a springy surface which closely approaches that of asphalt paving. The usual method of application is to scratch or break up the surface of the road to the depth of an inch or more, sprinkle on the oil by means of certain mechanical devices, and finally spread a thin coating of sand over the whole.

This soon becomes packed and the volatile constituents of the oil evaporate, leaving a dustless, springy surface of asphalt, soil, and sand. Several municipalities use the oil process entirely for their city streets and hundreds of miles of country roads in southern California are treated in a similar manner. A recent judicial ruling which holds that the principle of road oiling is not patentable has greatly stimulated this use for the heavy oils.[a]

PRODUCTION.

The gross production of petroleum in the Puente Hills district from 1899 to 1904, inclusive, was 8,241,081 barrels, as follows:

Production of oil in Puente Hills district, 1899–1905.

	Barrels.		Barrels.
1899	217,599	1903	2,545,318
1900	511,550	1904	2,328,064
1901	909,588	1905	2,007,021
1902	1,728,962		

These figures were compiled from data furnished by the officers of all the producing companies. Previous to 1899 the oil produced in this district came almost entirely from the Puente field.

PRICES.

The Union Oil Company has furnished the following table, showing the average price per barrel paid for crude oil (average gravity 18°–19° B.) at the wells in the Puente Hills district:

Average price per barrel, in cents, paid for crude oil at the wells, Puente Hills district.

	1901.	1902.	1903.	1904.	1905.
January	....	80	49	60	44
February	....	....	53	56	53
March	....	80	53	57	54
April	....	....	44	57	48
May	....	....	50	58	43
June	....	....	51	56	45
July	....	35–40	55	59	43
August	....	....	54	57	42
September	....	35–40	55	59	41
October	....	....	56	56	....
November	....	40	55	55	....
December	....	40	63	55	....
Average for year	80	60	53	57	46

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[a] For a detailed description of the road-oiling process see Prutzman, Paul W., Production and use of petroleum in California: Bull. California State Mining Bureau No. 32, 1904.

OIL COMPANIES IN PUENTE HILLS DISTRICT.

The following list gives the names of the companies that have put down wells in the different fields of the Puente Hills district, with the number of wells drilled by each. Those marked with an * are not operating.

Companies and number of wells in Puente Hills district, 1905.

Name of company.	Field.	Number of wells.
Brea Canyon	Brea Canyon	20
Buena Vista*	Puente	1
Bulla*	Whittier	3
Central of Los Angeles	do	46
Chandler (now Murphy)*	do	3
Chino Land and Oil*	Chino	4
Columbia Oil Producing (lease No. 2)	Olinda	12
East Whittier*	Whittier	2
Fidelity	do	9
Fullerton	Olinda	12
Fullerton Consolidated	do	16
Golden Gate*	La Habra	1
Graham-Loftus	Olinda	18
Hardison*	do	1
Holden*	Whittier	1
Home	do	18
Iowa*	Olinda	1
Joyce*	Whittier	1
Los Angeles Petroleum*	La Habra	1
Menges	Brea Canyon	2
Murphy	Whittier	21
New England*	La Habra	3
North Whittier*	Whittier	2
Olinda Crude*	Olinda	5
Palo Alto	Whittier	(?)
Palo Solo*	do	1
Pasadena	(?)	(?)
Price*	Whittier	1
Puente	Puente	65
Puente (Columbia lease No. 1)	Olinda	28
Santa Fe Ry	do	49
Strong*	Whittier	3
Turnbull Canyon	do	1
Turner	do	8
Union	Brea Canyon	30
Union (Sansinena)*	La Habra	9
Warner	Whittier	8
Whittier Consolidated*	do	2
Whittier Crude	do	9
Whittier-Filmore	do	2
Whittier Grand*	do	1
Whittier Oil and Development*	do	1
Whittier Producers*	do	1

THE LOS ANGELES OIL DISTRICT, SOUTHERN CALIFORNIA.

By Ralph Arnold.

INTRODUCTION.

During the summer of 1902 Mr. George H. Eldridge spent about two weeks in the vicinity of Los Angeles collecting data concerning the geology and oil production of the region, but owing to poor health for a long time previous to his death in 1905 he had done little toward working this information into a report. Since Mr. Eldridge's visit the city field has been considerably modified by the abandonment of many wells and the present state of development of the Salt Lake field has been brought about. It has therefore been necessary to make a new and more detailed examination of the same region in order to prepare a suitable report.

ACKNOWLEDGMENTS.

The writer wishes to fully acknowledge the value of Mr. Eldridge's notes, which have been freely used and which have contributed largely to whatever of value there may be in the following pages. Acknowledgments are due also to the various oil companies and their managers, as well as to individual drillers in the district, for assistance in various ways and for information given by them during the course of the work. Thanks are due more particularly to Mr. E. J. Eginton, superintendent of the Clark Oil Company; to Mr. A. F. Gilmore, of the Gilmore Oil Company; and to Mr. W. W. Orcutt, geologist of the Union Oil Company.

PREVIOUS KNOWLEDGE OF THE REGION.

After the researches of William P. Blake and Thomas Antisell, geologists accompanying the Pacific Railroad exploring expeditions, who visited southern California in 1853 and 1855, respectively, and of J. D. Whitney, State geologist, who went over portions of the same territory in the early sixties, no important geologic investigations in the region of Los Angeles or in the southern California oil fields in general were carried on until 1894, when W. L. Watts began a study of the petroleum deposits for the California State mining bureau.

Blake was the pioneer geologist in this region and his observations[a] are wonderfully accurate in view of the difficulties under which he and his associates worked. The part of his report relating to the southern California oil fields is that describing the region of the route traveled by his party, from San Francisquito Pass, north of Saugus, southward through Fernando Pass to Los Angeles and thence eastward to San Bernardino. He describes the east end of the Santa Susana Mountains, mentions Tertiary fossils found in Fernando Pass, and speaks of the eruptive rock (basalt) which outcrops in Cahuenga Pass. About 5 miles northwest of Los Angeles he found some "light-colored shales, thinly stratified, and charged with bitumen, which formed black and brown seams between the layers,"[b] and correlated them with the Miocene shale found in the vicinity of Monterey. Blake's only observations bearing directly on the oil question refer to the bitumen which he noticed exuding from the light-colored shale, and are as follows:[c]

> These places are known as tar springs, or pitch springs, and some of them form large ponds or lakes. One of the springs was passed on our way to the city, and was near the outcrop of bituminous shale in the banks of the creek already described. This spring was nothing more than an overflow of the bitumen from a small aperture in the ground, around which it had spread on all sides, so that it covered a circular space about 30 feet in diameter. The accumulated bitumen had hardened by exposure and its outer portions were mingled with sand, so that it was not easy to determine its precise limits. It formed a smooth hard surface like a pavement, but toward the center it was quite soft and semifluid, like melted pitch. The central portion of the overflow was higher than its margin; and it was evident that all the hard portion had risen in a fluid state and by the heat of the sun had been gradually spread out over the surface; at the same time being constantly exposed to dust, it had become so thoroughly incorporated with it that the compound had all the consistency of an artificial mixture. Tufts of "salt grass" were growing in some of the hollows and crevices of the outer portions of the hardened bitumen.

During the winter of 1854–55 an exploring party under the direction of Lieut. John G. Parke, accompanied by Dr. Thomas Antisell, geologist, examined the Santa Susana and Santa Monica ranges and the region adjacent to them as far east as San Bernardino. The results of this examination are set forth in Parke's report,[c] one chapter dealing with the geology of the two and another with the plains of San Fernando, Los Angeles, and San Bernardino. By far the most interesting chapter bearing on the oil question in Antisell's report is that on "Bituminous effusions," which gives a brief summary of all the then known bitumen deposits in the State. The following notes concerning the Los Angeles region are copied from this chapter:[d]

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[a] Pacific Railroad Report, vol. 5, pt. 2, 1856, pp. 65–88.

[b] Op. cit., p. 76.

[c] Pacific Railroad Report., vol. 7, pt. 2, 1857, pp. 75–86.

[d] Op. cit., pp. 112–113.

> *Deposits of Los Angeles Valley.*— . . . The asphalt is protruded through these strata near its contact with the argillite, forming distinct wells or springs, which overflow. The land where they lie is owned by Captain Dryden,[a] who at the time of the visit was sinking a pumping apparatus for hoisting up the bitumen, which is very liquid at this locality, where it forms a small pond a fourth of a mile in circumference, thinner in the center than at the edges. Like the other varieties, it readily dries and forms a solid pavement some yards around the edge of the wells. A large quantity is occasionally raised and sold at the rate of 40 gallons for $5—$1 for 8 gallons. It is in some demand for flooring and roofing. The quantity drawn at present seems to have no effect in diminishing the supply, but as intervals of rest occur, owing to the limited demand, it is difficult to say what continuous supply could be derived from this source. Mr. Trask, in his report (Doc. No. California, session 1855), calculates the amount of asphaltum in the counties of Santa Barbara and Los Angeles as not less than 4,000 tons. As he only mentions two localities, that near the village of Santa Barbara and this at the pueblo Los Angeles, it is presumed he reckons these as the only sources of his estimate. He does not state what the data of the calculations are. The actual quantity already poured out on the Santa Barbara shore is vastly greater than at Los Angeles—perhaps 6,000 tons would be an underestimate for Santa Barbara, but as a source of asphaltum it is extinct, while that at Los Angeles is actively pouring out, although the accumulated overflow is much smaller. As a locality of asphaltum available for the present time, Santa Barbara is preeminent; as a source for future wants, Los Angeles is preferable. By following the line of upheaval on these hills and making borings in the sandstone strata, the bitumen might be reached, and thus other sources than the natural well might be drawn upon. Doctor Trask values the asphaltum delivered in San Francisco at $16 per ton, but this is an excessive valuation according to the price at the well or according to the calculations of freight from Santa Barbara northward. Allowing the value to be $7 per ton, and in Los Angeles Valley about 2,500 tons to be at present available, the actual present wealth of the valley in bitumen would be $17,500. This, of course, does not take into account the future supply.

In addition to the descriptive matter Antisell gives a geologic section across the Santa Monica and Santa Susana ranges and another from San Pedro through Los Angeles to San Fernando.[b]

J. D. Whitney, State geologist from 1860 to 1874, describes the region from the San Fernando Valley north to the Bay of Monterey,[c] and in the same chapter enters into a discussion of the probabilities of finding oil in the Tertiary rocks of the Coast Range. He also severely arraigns the promotors of "wild-cat" oil companies, which, at the time of writing the report (1865), were preying on the credulous public. Another chapter is devoted to the geology of the Santa Monica and San Gabriel ranges and the vicinity of Los Angeles. The following are Whitney's notes concerning the brea deposits in what is now the Salt Lake field:[d]

> About 7 miles due west of Los Angeles is the most important of the numerous tar springs seen in this vicinity. It is from here that most of the asphaltum used in the town is obtained. Over a space of 15 or 20 acres the bituminous material (which, when seen by us, in the winter, had exactly the consistency and color of tar) was oozing

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[a] The "old Dryden well" is located about three-eighths mile north-northwest of Westlake Park.

[b] Pacific Railroad Rept., vol. 7, pt. 2, 1857, Pl. V, figs. 2, 3.

[c] Geol. Survey California, Geology, vol. 1, 1865, pp. 108-166.

[d] Op. cit., pp. 174-175.

out of the ground at numerous points. It hardens on exposure to the air and becomes mixed with sand and dust blown into it, and is then known as "brea." The holes through which the bitumen comes to the surface are not large, few being more than 3 or 4 inches in diameter. On removing the tarry substance from the holes, by repeatedly inserting a stick, the empty cavity was very slowly filled up again. At one place there was a pit several yards square and 6 or 8 feet deep, from which the tar had been taken, but it was filled with water at the time of our visit in consequence of late heavy rains. The brea is used almost exclusively for covering roofs at Los Angeles, selling (in 1861) at the springs for $1 per barrel, the purchaser collecting it himself, which is done by digging a pit 2 or 3 feet deep by the side of one of the holes from which the tar is issuing and letting it fill up. A very large amount of the hardened asphaltum, mixed with sand and the bones of cattle and birds, which have become entangled in it, lies scattered over the plain. Before 1860 the experiment of shipping it to San Francisco for the purpose of distilling burning oil from it had been tried, without success, at least in a pecuniary point of view.

A report on the geology of a portion of southern California, by Jules Marcou;[a] a paper on the petroleum, asphaltum, and natural gas of California, by W. A. Goodyear,[b] and a paper on the origin, composition, etc., of California petroleum, by F. Salathè,[c] complete the list of more or less important papers bearing on the geology and oil industry of the region about Los Angeles up to 1897.

In 1897 W. L. Watts issued the first[d] of his two reports largely devoted to the Los Angeles and adjacent oil districts. In this report he gives a brief outline of the geology of the territory discussed; lists and logs of productive, test, and abandoned wells, and notes on miscellaneous subjects, such as fossils of the oil-bearing formations, production, uses, and chemical and physical properties of the oil, refineries, drilling machinery, etc. Watts's second report,[e] although covering the California oil districts in general, is still largely given over to the fields of Los Angeles, Ventura, and Orange counties. Chapters are devoted to a discussion of the structural conditions pertaining to the occurrence and distribution of petroleum in California, the uses and chemical and physical characters of the oil, etc., and in addition there are brief reports on the fossils of the oil-yielding formations by J. C. Merriam, on the Humboldt County oil fields by F. M. Anderson, and on the oil-yielding formations of San Luis Obispo and Monterey counties by H. W. Fairbanks.

A paper by G. H. Eldridge,[f] in the Contributions to Economic Geology for 1902, is of interest not only on account of its comprehensive though short description of the individual fields, but also because it alone contains in epitomized form a number of the conclusions of this eminent authority regarding the California fields as a whole. A brief description of the Salt Lake field is given by the writer [a] in Contributions to Economic Geology for 1905.

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[a] Ann. Rept. U. S. Geog. Surv. W. 100th Mer., 1876, Appendix H 1, pp. 158-172.

[b] Seventh Ann. Rept. Califorina State Mineralogist, 1888, pp. 63-114.

[c] Thirteenth Ann. Rept. California State Mineralogist, 1896, pp. 656-661.

[d] Oil and gas yielding formations of Los Angeles, Ventura, and Santa Barbara counties: Bull. California State Mining Bureau No. 11, 1897, pp. x+94, 35 figs.

[e] Oil and gas yielding formations of California: Bull. California State Mining Bureau No. 19, 1900, pp. 236, 26 text figs., 35 half tones, 13 maps.

[f] The petroleum fields of California: Bull. U. S. Geol. Survey No 213, 1903, pp. 306-321.

A most useful bulletin relating to the technical and commercial phase of the oil question by Paul W. Prutzman [b] gives maps and other brief data in regard to the principal oil districts, together with detailed information concerning the character of the oil and its uses for fuel, for oiling roads, etc.

A short bibliography of the principal papers relating to the geology and technology of the Los Angeles and adjacent oil districts and to the oil industry of California is given on pages 199–202 of this report.

LOCATION AND TOPOGRAPHY.

The Los Angeles district, comprising the productive oil fields immediately north and west of the city, is located from 15 to 20 miles from the coast in the central part of southern California. Three transcontinental railroads—the Southern Pacific, the Atchison, Topeka and Santa Fe, and the San Pedro, Los Angeles and Salt Lake—pass through it, and steamers touch at Port Los Angeles, Redondo, and San Pedro, its ports of entry.

The city of Los Angeles occupies an area of about 15 square miles, the greater portion lying west of Los Angeles River at its debouchment from the low hills, which to the west pass gradually into the Santa Monica Range and to the east and north into the San Rafael Hills and Verdugo Mountains. To the southeast are the Raphetto Hills, which with the Puente Hills farther southeast constitute the connecting link between the Santa Monica and Santa Ana ranges. The Elysian Park hills north of the city trend northeast and southwest. Their southwestern slope is gentle and extends into the great Los Angeles-Santa Monica plain. Their northeastern slope is abrupt and parallels Los Angeles River. Northwest of the Elysian Park hills is the eastern extension of the Santa Monica Mountains, somewhat isolated from the main range by Cahuenga Pass, which trends northwestward from Hollywood, a suburb of Los Angeles. The mountainous area east of Cahuenga Pass is cut into sharp ridges and deep canyons and culminates in Cahuenga Peak at an elevation of 1,825 feet.

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[a] The Salt Lake oil field, near Los Angeles, Cal.: Bull. U. S. Geol. Survey No. 285, 1906, pp. 224–226, fig. 9.

[b] Production and uses of petroleum in California: Bull. California State Mining Bureau No. 32, 1904, pp. 230, 64 figs.

North of the Santa Monica Range lies the San Fernando Valley, separating this range from the Santa Susana Mountains on the north. South of the Santa Monica Range and the Elysian Park hills is the broad Los Angeles-Santa Monica plain, which slopes gently southward to the Inglewood hills, southwest of Los Angeles. A physiographic feature which appears to reflect in a general way the underlying structure—and if so may be important in determining the location of the productive territory—is the gentle declivity extending from the middle of the Salt Lake field northwestward toward Sherman.

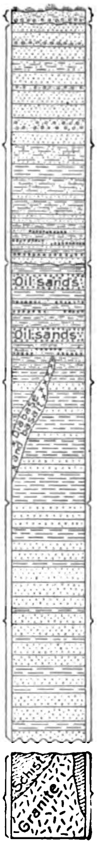
GEOLOGIC FORMATIONS.

Tentative correlation of oil-bearing formations of southern California with the standard California geologic section.

Period.	System.	Series.	Standard California section.	Santa Clara valley.	Los Angeles.	Puente Hills.
Cenozoic.	Quarternary.	Recent.	Alluvium.	Alluvium.	Alluvium.	Alluvium.
		Pleistocene.	San Pedro.	Sand and gravel.	Sand and gravel.	Sand and gravel.
			—Unconformity—	—Unconformity—	—Unconformity—	—Unconformity—
	Tertiary.	Pliocene.	Merced.	Fernando.	Fernando.	Fernando.
			Purisima.			
		Miocene.	San Pablo.			
			—Unconformity—	—Unconformity—	—Unconformity—	—Unconformity—
					Diabase intrusion.	Diabase intrusion
			Monterey.	Modelo. {Shale. Upper sandstone. Lower sandstone.	Puente. {Upper shale. Sandstone. Lower shale. (?)	Puente. {Upper shale. Sandstone. Lower shale. (?)
			Vaqueros.	Vaqueros.		
		Oligocene	San Lorenzo.	Sespe. {Upper. Red beds. Lower.		
			—Unconformity—			
		Eocene.	Tejon. Martinez.	Topatopa.		
Mesozoic.	Cretaceous.		—Unconformity?—	(?)		
			Chico. Horsetown. Knoxville.			
			—Unconformity—	—Unconformity—	—Unconformity—	
	Jurassic.		Granitic rocks of the Sierra Nevada.	Granitic rocks of the San Gabriel Range.	Granitic rocks of the Santa Monica Range.	
					Black schist.	

GENERAL STATEMENT.

The formations involved in the geology of the region about Los Angeles consist of (*a*) black micaceous schist; (*b*) a granitic series embracing diorite, gneiss, and other crystalline rocks; (*c*) more than 2,000 feet of Puente sandstone of lower Miocene age; (*d*) about 2,000 feet of upper Puente shale and soft, thin-bedded sandstone, also of Miocene age, (*e*) basalt and diabase intruding the previous formations, but older than the following: (*f*) 2,000 feet or more of soft, thin and thick bedded sandstone, thin-bedded shale, and heavy-bedded conglomerate of the Fernando formation, largely of Pliocene age, and (*g*) a capping of Pleistocene gravels and sands of variable thicknesses. (See fig. 12.)



	Feet.	
Quaternary	100+	Alluvium and roughly bedded gravel, sand, and clay.
Pliocene	2,000+	Upper portion thick-bedded soft sandstone with a few layers of conglomerate and thin-bedded sandy shale. Lower portion, largely thin-bedded soft clayey sandstone and sandy shale, somewhat petroliferous near the Miocene contact.
		Probable unconformity, beds of both formations having approximately the same dip.
Middle (and possibly upper) Miocene.	2,000+	Upper half, thin-bedded sandstone and sandy shale, with some hard siliceous members and one or two bands of coarse sandstone, which usually carry oil. Lower half, alternating bands of thin-bedded siliceous shale and coarse sandstone. This and all older formations intruded by diabase and basalt.
Lower Miocene	2,000+	Coarse, heavy-bedded brown arkose sandstone interbedded with minor quantities of argillaceous and siliceous shale, the shale being relatively more abundant toward the top and bottom of the formation. Total thickness unknown.
Pre-Cretaceous		Basement complex of diorite and other granitic rocks and gneiss, associated with an extensive dark-colored micaceous schist.

Fig. 12.—Generalized geologic section for the immediate vicinity of the Los Angeles oil fields.

BLACK SCHIST.

Black micaceous schist with a general northwesterly dip outcrops on the flanks of the Santa Monica Mountains about a mile northwest of Sherman and extends in a westerly direction along the south slope of the range for at least 15 miles. This schist is black to dark reddish brown in color, in some cases resembling certain hematite ores, and usually shows a very characteristic luster, due to the faces of the minute component mica flakes. Little is known concerning the age of these rocks except that they are older than the granite which bounds them on the east. It is certain, however, that they are pre-Cretaceous and very probable that they are Jurassic.

GRANITE.

A large part of the Santa Monica Mountains from the vicinity of Coldwater Canyon eastward to Los Angeles River is made up of granitic rocks similar in all respects to and probably contemporaneous with the granitic rocks which form the Verdugo hills, the northern part of the San Rafael hills, and the major part of the great San Gabriel Range to the north and east of the Santa Monica Mountains. In the region about Edgemont, northeast of Hollywood, the rock appears to be a fine-grained biotite granite, showing considerable quartz in hand specimens, although weathering precludes any exact determination of the composition. Biotite and hornblende granite, with some closely associated brown micaceous schist, appears to make up the larger portion of the crystalline area from Cahuenga Pass westward to Coldwater Canyon. With the possible exception of the western contact, which is probably one of deposition, the rock of the Edgemont area appears to be separated from the adjacent formation by fault planes, although the exact nature of the shale-granite contact north of Ivanhoe was not determined. The granite is younger than the black schist and is certainly pre-Cretaceous and probably late Jurassic in age.

PUENTE SANDSTONE.[a]

GENERAL CHARACTER.

The oldest Tertiary rocks so far discovered in the Los Angeles area consist of a heavy-bedded sandstone which overlies the pre-Cretaceous granite and schist on the flanks of the Santa Monica Mountains and makes up the bulk of the Elysian Park hills and the hills on the northeastern side of Los Angeles River from Gaston southeastward to the hills east of Eastlake Park. The lower part of the formation is somewhat argillaceous and may correspond to the lower Puente shale or to a portion of the Vaqueros formation, but the larger part is doubtless contemporaneous with the Puente sandstone of the Puente hills district. The best exposures of the Puente sandstone in the region about Los Angeles are in the Elysian Park hills, which are developed on the southern limb of a great anticline. (See Pl. XXI, *B*.) The formation as here developed consists of at least 2,000 feet of heavy-bedded, coarse-gray to rusty-arkose sandstone, interbedded at irregular intervals with dark-colored earthy and siliceous shale. The sandstone beds vary in thickness from 1 to 12 feet. Some are uniformly hard throughout, while others are concretionary, the concretions usually being elliptical in shape and in some cases coarser grained than the surrounding rock. As a rule, however, the sandstone is soft and falls an easy prey to weathering agents, being much less resistant than the interbedded shale. This differential weathering is well exemplified in certain ridges in Elysian Park, which cut transversely across alternate layers of the steeply dipping sandstone and shale, the latter forming prominent knobs at its outcrops along the top of the ridge. Jointing is well developed in the sandstone in certain localities, notably at the south end of Elysian Park, where hardening along the cracks of three different systems forms a kind of block structure. This is common in similar sandstones at many places throughout the Coast Range. In the region west of Edgemont and also along the flanks of the Santa Monica Mountains west of Sherman the basal beds of the Puente consist of conglomerate and sandstone, with appreciable amounts of interbedded gray to drab shale. The pebbles and cobbles in the conglomerate consist of granite rocks, diorite porphyry, quartzite, etc., some attaining a diameter of 3 feet. In the region of the basalt intrusions and flows about Cahuenga Pass the sandstone appears to have been slightly baked, and is harder, more jointed, and darker colored than in the Elysian Park hills. It may also represent a somewhat lower horizon than the Elysian Park rock.

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[a] See note regarding divisions of Puente formation on p. 103.

FOSSILS.

The Puente sandstone has yielded fossils in several localities in this region. In a street cut in Pasadena on the west side of Raymond Hill, about 2 miles northeast of the corner of the area shown in the accompanying map (Pl. XVIII) was found the following fauna:

Puente fossils from Raymond Hill, Pasadena, Cal.

Arca cf. montereyana Osmont.
Chione n. sp.? (small, with prominent concentric frills).
Leda cf. taphria Dall (Pl. XXXVIII, fig. 5).
Panopea generosa Gould.
Phacoides cf. acutilineatus Conrad.
Thracia n. sp.

Yoldia n. sp.
Agasoma barkerianum Cooper.
Natica or Neverita sp.
Turritella cf. variata Conrad (Pl. XLI, figs. 10, 11, 12).

Another fossiliferous locality is at Laughlins Hill, one-half mile southwest of Edgemont, where the following species were obtained:

Puente fossils from Laughlins Hill, north of Los Angeles, Cal.

Cardium sp. (large; sharp ribbed).
Pecten crassicardo Conrad (Pl. XXXI, fig. 1).
Phacoides cf. childreni.
Phacoides richthofeni Gabb.
Neverita callosa Gabb (Pl. XXXI, figs. 4, 4a).
Trophon sp.

The following fauna, characteristic of the lower Miocene throughout the southern San Joaquin Valley and as far south as the Santa Ana Mountains, is found at the head of Topanga Canyon, about 3 miles south of Calabasas, at the west end of the San Fernando Valley:

Puente fossils from 3 miles south of Calabasas, Los Angeles County, Cal.

PELECYPODA.

Callista (Amiantis) diabloensis Anderson.
Cardium sp. (sharp ribs).
Cardium sp. (square ribs).
Chione temblorensis Anderson (Pl. XXX, figs, 1, 1a).
Dosinia ponderosa Gray (Pl. XXXIII, fig. 4).
Glycymeris sp. (large).
Macoma cf. nasuta Conrad.
Mytilus mathewsonii Gabb var. expansus Arnold (Pl. XXX, fig. 2).
Ostrea titan Conrad (Pl. XXVII, fig. 2; Pl. XXXII, fig. 2).
Pecten bowersi Arnold (Pl. XXVII, fig. 1).
Pecten cf. miguelensis Arnold.
Phacoides richthofeni Gabb (Pl. XXXII, fig. 4).
Venus pertenuis Gabb.

GASTEROPODA.

Agasoma cf. kernianum Cooper.
Bittium sp.
Calliostoma sp.
Cancellaria cf. condoni Anderson (Pl. XXVII, fig. 9).
Cerithium topangensis Arnold (Pl. XXVII, figs. 7, 8).
Chlorostoma (Omphalius) dalli Arnold (Pl. XXVII, figs. 4, 4a, 4b, 5, 6, 6a).
Cylichna sp.
Dolichotoma keepi Arnold (Pl. XXXIII, fig. 5).
Drillia sp.
Fusus sp.
Macron merriami Arnold (Pl. XXVIII, figs. 4, 4a).
Neverita callosa Conrad (Pl. XXXI, figs. 4, 4a).
Ocinebra topangensis Arnold (Pl. XXX, fig. 4).
Purpura edmondi Arnold (Pl. XXVII, figs. 3, 3a).
Sigaretus perrini Arnold (Pl. XXVIII, fig. 5).

Trochita costellata Conrad (Pl. XXXII, fig. 3).
Trochita cf. inornata Gabb.
Trophon sp.
Turbo topangensis Arnold (Pl. XXVIII, fig. 6).
Turritella ocoyana Conrad (Pl. XLI, figs. 7, 8, 9).
Turritella variata Conrad (Pl. XLI, figs. 10, 11, 12).

The above fossils indicate that the beds in which they occur are of lower Miocene age and probably equivalent in general to the Vaqueros sandstone of central California.

UPPER PUENTE SHALE.

GENERAL CHARACTER.

Above the massive-bedded Puente sandstone and grading into it is a mass of strata at least 2,000 feet thick, in which shale beds of one sort or another largely predominate. No sharp line of demarcation separates this shale from the sandstone beneath, but as a whole they are radically unlike. The two members are differentiated on the map (Pl. XVIII) along a line which, it is thought, marks the boundary between the preponderance of the sandstone facies on the one hand and the preponderance of the shale on the other. The shale in the region north of Los Angeles may be roughly divided into two approximately equal parts, the lower 1,000 feet consisting of broad bands of thinly laminated white to gray shale interbedded with similar bands of more or less thick-bedded, coarse yellowish to brown sandstone, and the upper 1,000 feet or more being characterized by thin-bedded sandy and clayey shale and thin to medium bedded sandstone. At the top of the shale series is a band of thin-bedded hard white siliceous shale, interstratified with 2 to 4 inch layers of brown sandstone. The top of this band is used in mapping as the arbitrary line between the Puente formation and the overlying Fernando (Pliocene) sandstone.

Most of the shale in the lower part of the member, and also many of the shale beds interstratified with the Puente sandstone, are of the hard white siliceous variety characteristic of the Monterey shale in the Coast Range. This shale splits easily along the bedding planes into thin, sharp-cornered plates. Fragments of these scales or plates, which are very resistant to weathering, are often found scattered over the ground and thus indicate the presence of the beds over areas in which outcrops may be rare. Abundant minute organic remains are usually found in the siliceous layers, but no recognizable molluscan forms have so far been obtained from them in this region. In the territory northeast of Los Angeles the structure is complex and an exact determination of the position of the shale is impossible; but it is probable that most of it belongs to the upper part of the Puente formation. In the vicinity of Sycamore Park the rock consists of at least 400 to 500 feet of very dark colored, highly carbonceous, thinly laminated gypsiferous shale, showing traces of sulphur on the weathered surfaces. Associated with this is dark-brown sandy shale, interstratified with yellowish limy layers containing gray to yellowish calcareous elliptical concretions as much as 5 feet in length. Thin-bedded white chalky shale containing numerous fish remains is also found a little to the southwest of Sycamore Park. In the region about the mouth of Cahuenga Pass, where the shale is intruded by diabase, it is much contorted and fractured, gray to discolored blue gray and rusty brown in color, in places gypsiferous, and much of it tending to concretionary structure.

The upper 1,000 feet or more of the upper Puente shale consists principally of soft, thin-bedded clayey to sandy shale, varying in color from gray through light yellow to rusty brown and locally, where oil bearing, to bright tints of yellow and pink. A peculiar efflorescence characterizes the weathering of the sandy members of these upper beds in many places. At the top of the formation are two bands of thinly laminated, alternating hard white and soft drab shale, separated by about 125 feet of coarse sandstone, the latter being shown on the map (Pl. XVIII) by a special legend. These two shale bands, with their interbedded and underlying thin-bedded sandstone, mark the principal oil-bearing zone in the Los Angeles district.

Associated with the shale at the top of the lower half of the upper Puente shale is a 50-foot band of coarse arkose sandstone, which is shown on the map in the same color as the Puente sandstone.

OIL SANDS.

As mentioned in the preceding section, the productive oil sands occur interbedded with the shale near the top of the Puente formation. Exposures of these sands are to be found almost continuously along the mapped oil-sand zone, running from the Sisters' Hospital, on Sunset boulevard, to the bend in the Hollywood and Cahuenga Valley Railroad, on Western avenue. The surface exposures of the upper sands, which aggregate about 125 to 150 feet in thickness, usually either are more or less impregnated with oil or asphaltum or else by their color show the effects of its former presence in the beds. These sands vary in color from brown to dark drab and in some instances show bright tints of pink, purple, and yellow. As a rule they are coarse and in places, notably toward the west end of the district, they are more or less finely conglomeratic. The concretionary tendency is also characteristically shown in certain of the beds. In the low hilly region flanking the Elysian Park hills on the west what is supposed to be the equivalent of a part of the oil sands is characterized by large, hard concretions. (See Pl. XXI, *A*.) At one place these concretions are round, while at others they vary from elliptical to irregular; they are usually 4 feet or less in diameter. In some of the layers of this band the grains of quartz and feldspar attain a diameter of three-eighths of an inch, in others the grain is finer. The color of the sands here varies from gray through light yellow to purple, the latter color indicating the former presence of oil in the rock.

About 300 feet stratigraphically beneath the upper oil sands is the second productive layer. This consists of 40 to 50 feet of thick to medium-bedded arkose strata, similar in all practical respects to the upper sands. Between these two principal layers and in the shale beneath the lower are other sandy beds, which are shown by the well records in the west end of the field to be more or less productive. The great bulk of the oil, however, is derived from the two principal layers just described.

MIOCENE BASALT.

Large masses of basalt are associated with the Puente sandstone and shale in the region about the mouth of Cahuenga Pass and to the east as far as Laughlins Hill. From evidence to be obtained at different localities in this region, both intrusive masses and surface flows are represented by the rock. Outcrops of a spheroidal type, such as that forming the little knoll three-fourths of a mile northwest of Hollywood, indicate the intrusions, while the vesicular facies found in the east end of Laughlins Hill tends to prove the existence of the flows. The usual color of the weathered outcrops is purplish red to reddish brown, the overlying soil in nearly all cases partaking of the characteristic color of the underlying rock. The igneous rock in the knoll three-fourths of a mile northwest of Hollywood, although doubtless genetically identical with the fine-grained basalt lying farther east, somewhat resembles in hand specimens certain forms of diabase.

The age of the basalt is the same as that of similar rocks found north and northwest of Santa Monica in the Santa Monica Mountains, also in the Puente Hills, north of Brea Canyon, and in many regions of the Coast Range at least as far north as the Santa Cruz Mountains. The rock intrudes or is interbedded with the Vaqueros sandstone and Monterey shale or contemporaneous formations at one locality or another, but is unknown, except as worn pebbles in conglomerate, in any of the later formations. It is therefore of middle Miocene age.

FERNANDO FORMATION.

GENERAL CHARACTER.

The line of demarkation between the Miocene and Pliocene formations in the region about Los Angeles is not at all distinct. There is no doubt of the existence of a decided break between the white shale of the Miocene and the upper fossiliferous sand and conglomerate of the Pliocene, represented by a period of deformation and subsequent erosion. Just what plane in the stratigraphic sequence of beds marks this period, however, has not been determined. The interbedded conglomerate found in the fossiliferous lower Pliocene sandstone contains numerous waterworn and pholas-bored fragments of the characteristic white Miocene shale, and this evidence clearly proves the conditions of a break or unconformity. A marked unconformity is usually discernible between the Monterey shale and subsequent formations at most places throughout the Coast Range where the two formations are in contact, so that it is not at all surprising to meet this evidence here. Over many areas, both north and south of the Los Angeles district, similar evidence is corroborated by the presence of marked structural unconformities. Here this latter evidence appears to be lacking.

It is necessary, therefore, to draw an arbitrary line separating the two formations. Because of the almost complete absence of the hard white siliceous shale from the Pliocene (Fernando) the line separating the Miocene (Puente) and the Pliocene (Fernando) has been drawn at the top of the uppermost layer of hard, white shale. This line is probably somewhat lower than if it were drawn on paleontologic evidence. In other words, the lower part of what is here termed the Fernando formation (Pliocene) is possibly Miocene and may be contemporaneous with some portion of the San Pablo (upper Miocene) of central California.

The basal portion of the Fernando formation consists of about 500 feet of soft to compact, thin-bedded sandstone and sandy shale, with some zones in which the shale is fine grained and clayey. (See Pl. XXIV, *A*.) The color of the beds ordinarily varies from gray and light yellow to rusty brown, except in those strata that are or have been impregnated with oil, many of which are chocolate, purple, or bright yellow. Above the purely sandy strata is a zone about 500 feet thick in which some of the shale is calcareous and very hard. Some of this hard shale, especially that which shows a tendency to concretionary structure, closely resembles certain of the Miocene shales. This zone of calcareous shale is also rich in gypsum, some of the veins being 2 inches wide. Most of the veins occur between the bedding planes of the shale, although some cut the strata transversely.

Above the shaly portion of the Fernando are thick-bedded, soft gray to light-yellow sandstone and coarse conglomerate associated with some thin-bedded bluish-gray sandy shale or shaly sandstone. The thin beds of conglomerate in this portion of the formation are those already mentioned as being composed largely of waterworn and pholas-bored fragments of the siliceous Puente shale. This conglomerate, as well as the sandstone and sandy shale, yields a characteristic lower Pliocene marine molluscan fauna. The thickness of the upper part of the formation is somewhat problematical, although the evidence at hand shows that it is 1,000 feet or more, making the total thickness of the Fernando over 2,000 feet.

The areal distribution of the formation is most interesting when considered in its relation to the Puente. In the region of the oil belt the Fernando rests upon the uppermost Puente white shale in a great southward-dipping monocline. East of the oil belt and Los Angeles River this simple relation seems to be changed. Here, in the meager exposures afforded by rare gaps in the Pleistocene and alluvium deposits, occur what appear to be the lower, thin-bedded sandstone and sandy shale of the Fernando in contact with the Puente sandstone, the white shale apparently being absent through the agency either of an unconformity or of a fault, or of both combined. The Fernando also extends southeastward to San Gabriel River, comprising the bulk of the sediments of the Raphetto hills, the west end of which is shown on the map. (Pl. XVIII.)

FOSSILS.

The following fossils were obtained by Homer Hamlin from the Third street tunnel in Los Angeles and indicate the lower Pliocene age of at least this part (upper sandstone, sandy shale, and conglomerate) of the Fernando formation:

Lower Pliocene fossils from the Fernando beds in the Third street tunnel, Los Angeles.

Arca multicostata Sowerby (Pl. XXXVIII, fig. 1).
Astarte sp.
Lima hamlini Dall.
Macoma sp. indiv.
Ostrea veatchii Gabb (Pl. XXXIX, fig. 1).
Pecten ashleyi Arnold (Pl. XXXIV, fig. 2).
Pecten latiauritus Conrad (Pl. XXXVI, figs. 2, 3).
Pecten opuntia Dall (Pl. XXXVI, fig. 8).
Pecten pedroanus Trask (Pl. XXXVI, figs. 5, 6).
Pecten stearnsii Dall (Pl. XXXV, fig. 2).
Buccinum sp. indet.
Fissuridea murina Carpenter (Pl. XL, figs. 3, 3a).
Nassa hamlini Arnold (Pl. XL, fig. 9).
Neverita recluziana Petit (Pl. XXXVIII, fig. 6).
Pleurotoma sp. indet.
Priene oregonensis Redfield var.? angelensis Arnold (Pl. XL, fig. 11).

The following is a list of fossils collected by W. L. Watts in the vicinity of Los Angeles and largely identified by J. G. Cooper:[a]

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[a] Bull. California State Mining Bureau, No. 11, 1897, pp. 79-81.

Pliocene fossils from Los Angeles and vicinity.

Name.	Los Angeles oil wells.	Well on Green-Meadow ranch.	Shatto estate, West Los Angeles.	Normal school, Los Angeles.	Other localities.
Bittium asperum Gabb				×	
Calliostoma costatum Martyn				×	
Carcharodon rectus Agassiz			×		
Cancellaria tritonidea Gabb			×	×	
Cerithidea californica Haldeman	×				
Chama exogyra Conrad	×				
Clathurella conradiana Gabb	×				
Corbula luteola Carpenter				×	
Crepidula princeps Conrad	×		×	×	
Cryptomya californica Conrad			×	×	
Drillia n. sp. (?)					Hays Canyon.
Diplodonta orbella Gould				×	
Glycymeris barbarensis Conrad	×				
Hinnites giganteus Gray	×				
Kellia suborbicularis Montague		×	×	×	Reynolds & Wiggins well, Los Angeles.
Laqueus californicus ? Koch					Temescal Canyon.
Lithophagus plumula Reeve				×	
Macoma inquinata Deshayes	×				
Macoma nasuta Conrad	×			×	
Mactra californica Conrad			×	×	
Mitra maura Swainson	×				
Nassa fossata Gould		×		×	
Nassa californiana Conrad				×	
Nassa mendica Gould		×		×	
Nassa perpinguis Hinds		×			
Neverita recluziana Petit					First and Olive streets, Los Angeles.
Ocinebra lurida Middendorff		×			
Ostrea veatchii Gabb	×				Brown Canyon.
Oxyrhina plana Agassiz			×		
Oxyrhina tumula Agassiz			×		
Petricola carditoides Conrad		×	×	×	
Pecten auburyi Arnold				×	
Pecten healeyi Arnold					Temescal Canyon.
Pecten pedroanus Trask				×	Clark estate, Los Angeles.
Pecten stearnsii Dall					Hays Canyon, Brown Canyon.
Periploma discus Stearns					First and Olive streets, Los Angeles.
Phacoides californicus Conrad					
Placunanomia n. sp	×				
Platyodon cancellatus Conrad	×				
Saxidomus gibbosus Gabb			×		
Semele decisa Conrad	×				
Tapes staleyi Gabb			×		
Tellina idea Dall				×	
Terebratalia occidentalis Dall					Temescal Canyon.
Venericardia ventricosa Gould					Reynolds & Wiggins well, Los Angeles.

PLEISTOCENE.

GENERAL CHARACTER.

The Pleistocene deposits in the Los Angeles region comprise gravel, sand, and clay, the first mentioned predominating. The gravel and sand capping the Fernando in the region of the oil belt and farther south, especially on the top of the ridge on which the normal school is situated, are probably of marine origin; the rest of the deposits are largely fluviatile.

The thickness of the Pleistocene, especially along the southern edge of the area mapped, is probably 300 to 500 feet, while in certain of the terrace deposits, such as those on the hills north of Sherman and on the terraces flanking Los Angeles River and Arroyo Seco, it may be only from a few inches to, say, 50 feet.

BREA DEPOSITS.

In the region immediately northwest of the Baptist College, in the territory one-half to three-fourths mile southwest of Colegrove and on the south side of the Rancho la Brea the Pleistocene and alluvial deposits are impregnated with asphaltum, forming brea. This material originates in two ways—heavy oil or asphaltum exudes from the surface and becomes filled with drifting dust and sand, or the fluid exuding from the underlying hard strata impregnates overlying porous gravel and sand. Details concerning the brea deposits are quoted under the heading "Previous knowledge of the region," the older geologists having had an exceptional opportunity for studying these "tar springs," which at the time of their visits were almost untouched and much more extensive than at present. In the Rancho la Brea deposits at the south side of the Salt Lake oil field many bones of extinct mammals have been found. (See Pl. XXIV, *B.*) The following notes concerning these remains are quoted from an unpublished manuscript by Dr. J. C. Merriam:

> The beds in which the bones occur extend over many acres. So far as I am aware the bottom has not been reached in excavations carried on to the depth of at least 15 feet in quarrying the asphalt. Bones are scattered through a large part of the deposit, but are very unevenly distributed. In some localities they are present in large numbers and in fairly defined layers.
>
> The asphalt has in many cases penetrated even the minute pores of the bone, but the original material of the skeleton is itself practically unchanged.
>
> The remains recognized up to the present include the following: *Elephas*, *Equus*, *Bison*, *Mylodon* (?), *Smilodon*, *Canis indianensis* (?), *Canis* small species and camel remains. Numerous bird bones and remains of insects are also found.
>
> In a considerable number of cases large parts of the skeleton are found together, showing that the carcasses were entombed so quickly that there was not sufficient time for decomposition to permit separation of the parts.
>
> Of the remains recognized up to the present time, an extraordinarily large percentage represents Carnivora. The number of carnivores is certainly relatively larger than the usual percentage in a well-balanced fauna, and this abundance must be attributed to peculiar conditions under which the bones accumulated. Undoubtedly most of the remains are those of animals that have been entrapped or mired in the asphalt at times when it formed a sticky deposit around tar springs. The surface of the asphalt is very sticky in some places at the present time, and where cuts are opened in it tar may ooze out. Such pools have probably existed here interruptedly through a long period, and particularly during Quaternary time when the deposit was forming. Carnivores are numerous, because they were attracted by birds and mammals caught in the asphalt. Perhaps it is not entirely a coincidence that the carnivore remains are usually associated with those of birds or mammals, which would be their natural prey. The considerable number of young saber-tooth cats present may indicate that the younger and less experienced individuals were more easily lured into the tar pools.

Aside from their scientific value, these bones have the added significance of indicating that the brea-forming conditions which are now prevalent in this field were in operation during a large portion of Pleistocene time. In view of the great number of years during which the gas and oil have been escaping in this field, it seems rather remarkable that such prolific deposits of petroleum are still to be found in the underlying strata. These facts indicate the almost incomprehensible amount of oil that was originally contained in the Tertiary rocks over certain areas of the Coast Range belt.

STRUCTURE.

GENERAL FEATURES.

The structural features in the region about Los Angeles are dependent on two systems of disturbances. The older of these consists primarily of folds, with which are usually associated minor faults. This system dominates the Miocene strata and was probably largely developed during the post-Puente (late middle Miocene) readjustment, which had such a widespread effect throughout the Pacific coast of the United States. The axes of disturbance of the Miocene system trend, approximately, N. 60° W. The younger system, in which faults are apparently the dominant features, was developed during late Pleistocene time and affects all the formations in the area. The general trend of the axes of the Pleistocene system is east and west. Minor faults with planes striking in various directions are common throughout the district.

The most prominent structural feature in the district is the great flexure in the Puente sandstone and shale which lies northeast of the business portion of Los Angeles and trends N. 60° W. This will be referred to as the Elysian Park anticline. (See Pl. XX, sec. E–F.) This anticline might almost be regarded as an elliptical structural dome, as it appears to plunge at both its northwest and southeast ends. Not far from the northwest extremity of the anticline where it approaches the fault zone lying along the southern base of the Santa Monica Mountains the fold develops into a fault. Near the axis of the anticline the beds in the southern limb dip gently, the slope becoming steeper and steeper, however, toward the south until, in the region of the shaly beds, dips of 60° are not uncommon. The northern limb is obscured by erosion, but the rocks composing it appear to dip at angles as great as 40°. Toward the south end of the anticline minor flexures are developed on its flanks and these in turn are squeezed up into what appears to be one or more closely folded overturns in the hills 1½ miles east of Eastlake Park. Other folds of considerable extent and at least one prominent fault trending approximately in the same general direction as the Elysian Park anticline are exhibited in the Puente shale and sandstone to the northeast of the major flexure. Many of these latter folds are very sharp, dips of 60° or more being the rule. They are doubtless the result of tangential compressive stresses. South of Eastlake Park are violently disturbed beds whose structure is rather uncertain. Apparently, however, they lie in a closely compressed anticline, with axis trending in a general east-west direction along a line making a compound curve. This fold affects beds of probable Fernando age. The apparent analogy of this anticline, if such it be, to those in certain oil-producing areas of southern California leads to the inference that oil may be confined beneath it. However, those wells which have been put down east of Los Angeles River have not proved successful.

Southwest of the Elysian Park anticline is a syncline accompanied by a zone of faults. This flexure extends from the region southeast of Prospect Park in a broad northeasterly convex curve to the vicinity of the Sisters' Hospital on Bellevue avenue and separates the steeply dipping shale on the northeast from the softer flatter beds of the rolling-hill country southwest of the line of disturbance. (See Pl. XX, sec. E–F.) The southern extension of this syncline is traceable as a fault from the corner of Sunset boulevard and Sutherland street to a point just south of Innes street and thence southeastward toward the Sisters' Hospital, and is doubtless responsible for the breaks in the productive oil belt which occur in the vicinity of the hospital.

The most prominent structural feature belonging to the east-west Pleistocene system is the fault zone extending along the southern face of the Santa Monica Mountains from Los Angeles River at least as far as Hollywood and probably much farther west. (See Pl. XX, sec. C–D.) This fault zone has been largely instrumental in the formation of the range. It allows the upper Puente shale to come into contact with the granite, from which it is ordinarily separated by at least 2,000 feet of conglomerate and sandstone. Associated with this profound displacement are minor parallel faults in a zone which is characterized by many fractures and much distortion of the strata.

STRUCTURE OF THE OIL BELT.

The Los Angeles oil field is developed in strata at the top of the Puente formation on the southern limb of the great Elysian Park anticline. (See Pl. XX, sec. E–F.) The trend of the productive belt, however, instead of conforming to the axis of the main fold follows the strike of the formations on the south side of a divergent subordinate fold and hence has assumed a direction closely approximating east and west. The axis of the subordinate fold is traceable from a point near the corner of Lake Shore avenue and Temple street south of Echo Lake, westward to a point north of Westlake Park where its trend changes to N. 70° W. Thence it passes westward at least as far as a point 1 mile southeast of Colegrove, where it is probably deflected still farther north of west and merges with the great anticline which tilts the Puente sandstone in a northeasterly direction on the west side of Cahuenga Pass. (See Pl. XX, sec. C–D.) Between Lake Shore and Bellevue avenues the fold either blends with the Elysian Park anticline or is replaced by some undiscovered fault or other form of disturbance. The latter theory is strengthened by the evidence obtainable both east and west of the Sisters' Hospital where directly in line with an eastward extension of the fold there is a sharp line of disturbance (probably a complicated thrust fault) which extends to the east end of the field at the Catholic cemetery. (See Pl. XX, sec. G–H.) Another line of fracture, consisting of several more or less disconnected minor reverse faults, lies south of the subordinate flexure just described and toward the west diverges slightly from it. (See Pl. XX, sec. E–F, and fig. 13, p. 171.) This fault zone appears in general to mark the northern boundary of the productive belt. As a rule the beds lie nearly horizontal along the axis of the flexure, but dip more and more steeply toward the south as they approach the productive zone. The oil appears to have accumulated in the sands of the southern limb of the anticline just below the point where the steeply dipping beds bend toward the horizontal before passing over the axis of the fold. The structure in the Salt Lake field, in the southern part of the Rancho la Brea, appears to be that of a minor flexure developed on the flanks of the fold along the southern limb of which the other Los Angeles fields are located. (See fig. 17, p. 189.) Apparently the axis of this minor flexure trends northeast and southwest. The brea along the south side of the Salt Lake field is formed by oil from underlying beds which probably has been forced upward by gas pressure along lines of fracture accompanying this flexure.

JOINT CRACKS.

All the rocks in the Los Angeles district are intersected by numerous joint cracks, along which, in many instances, slight displacements have taken place. These tiny fissures have doubtless played a most important part in the accumulation of the oil, for it is probable that whatever was its original source the transverse joint cracks in the shale and sandstone are largely responsible for its transference to the upper porous beds of the formation. Without these cracks the numerous impervious beds in the series would have precluded the passing of any fluid, least of all low-gravity oil, upward through the strata.

OIL FIELDS.

LOCATION.

The oil-bearing zone begins near the Catholic cemetery on Buena Vista street, at the southern base of the Elysian Park hills, and trends in an almost westerly direction to a point north of West Lake; here it bends to N. 60° W. and extends into the region south of Colegrove. Two miles southwest of Colegrove, on the almost level Los Angeles-Santa Monica plain, is the field locally known as the Salt Lake (so named from the principal company operating there), which, though topographically isolated from the main Los Angeles field, is, nevertheless, probably genetically related to it. In discussing this subject it has been deemed advisable to divide the productive territory into four parts, differentiated more or less sharply along structural lines. The area extending eastward from the Sisters' Hospital to the eastern limit of the productive territory at the Catholic cemetery will be described as the eastern field; that extending from the hospital to a line passing northward through West Lake as the central field; that extending northwestward from the region about the Baptist college as the western field; and that on the Rancho la Brea, southwest of Colegrove, as the Salt Lake field. (See Pl. XIX.)

DEVELOPMENT.[a]

The development of the Los Angeles oil district has taken place spasmodically, four periods of activity marking its history. The first period, during which the central field was first opened, covers the time from late in 1892 to 1895; the second, in which the eastern field was developed, includes 1896 and 1897; the third, or period of exploitation in the western field and the west end of the central field, embraces 1899 and 1900; and the fourth, which marks the development of the most important part of the district, the Salt Lake field, extends from 1901 up to the present time.

The history of the Los Angeles oil wells, or, more properly speaking, of the Second Street Park oil field at Los Angeles, is as follows: For many years a small deposit of brea was known to exist on Colton street near Douglas street, in the city of Los Angeles, and the brea was locally used for fuel. In 1892 Messrs. Doheny & Connon sunk a 4 by 6 foot shaft, 155 feet deep, at the corner of Patton and State streets, close to the deposit of brea previously mentioned. The formation penetrated is sandy shale, with a few thin strata of siliceous or calcareous rock. Near the surface the oil was very heavy, but at about 7 feet deep it was found to be lighter and it seeped from the sides of the shaft. The oil exuded from porous material and from the surface planes of the hard strata. The formation was found to dip toward the south at an angle of about 40°. Excavation below a depth of 155 feet was prevented by gas. An 18-inch hole was then drilled in the bottom of the shaft and yielded 7 barrels of oil daily for several weeks. In July, 1894, the yield had decreased to 2 barrels of oil a day. In November,

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[a] The writer is largely indebted to the reports of W. L. Watts for data of a historical character used in this paper.

1892, an oil well was sunk at Second Street Park by Messrs. Doheny & Connon. As soon as this well was found to be a success other wells were sunk on adjacent lots, and the Second Street Park oil field grew rapidly. By the end of 1895 there were more than 300 wells within an area of less than 4,000,000 square feet. During 1895 the price of crude oil at Los Angeles fell to a ruinously low rate, the average price for that year being 60 cents a barrel. Indeed, there were sales at a much lower rate—it is said even as low as 25 cents a barrel. The reason for this depression was the lack of cooperation among the oil producers and the lack of facilities for storing and handling the oil. Early in 1896 the price of oil commenced to recover, and in July, 1896, it had reached $1 a barrel. The reason of this recovery was the diminishing of the supply, the organization of the oil producers, and the increased facilities for storing and handling the oil.[a]

Development in the central field proceeded eastward until it encountered the disturbed and barren beds in the region just west of the Sisters' Hospital, where exploitation ceased. On the theory that this break was only local and that the productive zone continued eastward along the strike of the oil-bearing strata, a well was sunk by Maier & Zobelein at the corner of Adobe and College streets, in what is now the eastern field. This well was completed in November, 1896, and as soon as it was found to be successful many other wells were begun in the immediate vicinity, and by the middle of 1897 the wells in the new field were almost as closely crowded as those in the old or central territory. Prospecting was continued east of Los Angeles River, but no economically productive wells were developed.

The exploitation of the western field and the extension of the central field from the corner of Quebec street and Ocean View avenue westward took place largely during the latter part of 1899 and 1900. Some wells, notably the Ruhland, at the corner of Seventh and Hoover streets, and several of the Maltman wells, north of the Baptist college, however, were sunk previous to 1897.

The entrance of the Salt Lake Oil Company into the Rancho la Brea region in 1901 marks the beginning of the development of the field now bearing that company's name. For years the oil seepages and brea on this ranch had been known, and large quantities of brea had been hauled away for paving purposes. At least one prospect well had been put down near the brea deposit, but no important results were obtained from any of these operations. The first well drilled by the Salt Lake Company was abandoned on account of the caving in of the casing, caused by gas pressure. This fact being construed as a good indication, several other wells were sunk in the same locality until finally a "gusher" was struck and the value of the field assured. Since the beginning of 1902 the development in this territory has been rapid, and now it stands first in importance among the oil fields south of Santa Barbara County.

Owing to the proximity of the wells to each other the oil-bearing strata in the central and eastern fields have been rapidly exhausted, and many of the once-productive wells are now abandoned. During the past year (1905) the council of the city of Los Angeles took cognizance of this fact, and in order to do away with the nuisance of abandoned wells and pumping plants in a thickly populated residence quarter outlined certain districts within which all traces of the oil industry are to be removed within a certain period. This policy, if carried out, will eventually result in the abandonment of the city fields, so that probably in only a few years the thickly set derricks which now extend through the northern part of the city will be a thing of the past.

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[a] Bull. California State Mining Bureau No. 11, 1897, p. 5.

EASTERN FIELD.

LOCATION.

The eastern field comprises that portion of the productive oil territory of Los Angeles which lies between the Sisters' Hospital grounds, corner of Sunset boulevard and Beaudry avenue, on the west, and the Catholic cemetery, corner of Cottage Home and Buena Vista streets, on the east. Its northern boundary is a line running from the northern part of the hospital grounds eastward to a point on the western line of the cemetery 600 feet north of Buena Vista street; its southern limits are Alpine street from the hospital southeastward to Figueroa street, and thence a line slightly north of east to the southwest corner of the cemetery. This area is nearly three-fourths of a mile long, with a maximum width of about 1,000 feet near the middle and a minimum of less than 400 feet at the ends; it contains approximately one-eighth of a square mile.

TOPOGRAPHY.

The eastern field lies on the southwestern flank of the Elysian Park hills, along the southern faces of the two well-developed minor ridges which are separated by Chavez Ravine. The topography, however, appears to have no connection whatever with the structure of the field or the extent of the productive zone, the line of wells forming an approximately straight belt from the low southwestern slope of the western ridge at the Sisters' Hospital, up over the face of this same ridge, down into and across the mouth of Chavez Ravine, and eastward over the lower portion of the eastern ridge.

GEOLOGY.

All the formations from the Puente sandstone to the Fernando beds are involved in the geology of the eastern field. North of the field and forming the bulk of the Elysian Park hills is the thick-bedded gray to light-yellow and rusty-brown sandstone of the Puente formation. This outcrops along some of the park roads and is exceptionally well exhibited on Buena Vista street east of the field and west of Los Angeles River, where the peculiar jointing features, previously described, are prominently developed. Above the sandstone is the typical white siliceous shale, which extends in a broad band from the region of the Catholic cemetery northwestward along the flank of the Elysian Park hills. At the northwest corner of the cemetery this shale is very much crumpled, but northwest of this point it appears to be little distorted and dips about 45° S. 30° W. The top of the shale is marked by a 50-foot band of heavy-bedded, coarse light-yellow to brown concretionary sandstone, which is well exposed on the southwest side of Sunset boulevard near its intersection with Sutherland street. At the west end of this exposure the sandstone is cut off by a fault which has thrown some shale beds down against the sandstone on the west. The sandstone, together with its underlying and overlying white-shale bands, may be traced in a southeasterly direction from the locality last mentioned toward the oil field as far as the quarries on the west side of the Chavez Ravine road. Its dip along this line is also 45° S. 30° W. What is probably a continuation of the same sandstone band is exposed on the east side of the ravine a short distance north of the corner of Adobe and Bernardo streets, but the rocks here are so near the fracture zone and so much disturbed that the correlation is more or less uncertain. This sandstone layer and its associated shale are easily differentiated in old surface exposures, but in fresh road cuts and quarries their identification is more difficult. The overlying band of shale, which is characteristically thinly laminated and of flinty siliceous composition, underlies a considerable thickness of medium- to thin-bedded soft sandstone and sandy shale. These beds are well exposed in the brick company's quarries on the southwest side of Chavez Ravine. At the sharp bend in Figueroa street on the south end of the ridge west of the ravine, and extending westward at least as far as Ramona street just north of its intersection with College street, is another band of thin-bedded white shale which normally lies above, but which here is probably faulted down against the soft sandstone and sandy shale last described. This white shale is similar to that lying above the oil sands in the region west of the Sisters' Hospital and, like it, is much more resistant to weathering than the oil sands. If the two shales are identical it would be reasonable to suppose that the oil sands lie only a short distance beneath the shale at the Figueroa and Ramona street outcrops. This supposition is borne out by the wells only a short distance south of the white-shale outcrop, which strike productive sands at depths somewhat greater than 600 feet. Owing to the faulting down of the oil-bearing beds against the older strata on the north, no outcrops of the oil sands have so far been discovered in the eastern field. The beds overlying the oil zone are similar to those found in the same position in the central and western fields and consist largely of soft, thin-bedded sandstone and sandy shale, dipping approximately S. 10° W.

GEOLOGY OF THE WELLS.

The underground geology of the eastern field is similar to that of the central, and is what would be expected from an examination of the surface evidence in the region. Within the productive territory the wells first penetrate the sandy shale of the Fernando, after which they enter the Puente clayey shale and "shell" beds which mark the top of the productive zone. Oil occurs in two sands, the upper being about 55 feet and the lower about 25 feet thick. At the present time the upper sand is practically exhausted, having been pumped continuously for nearly seven years. Ten or twelve barrels per day was not an unusual yield when the sand was first struck, and even three years ago some of the wells were still yielding 1 or 2 barrels. The gravity of the oil in the upper sand is said to be between 18° and 19° B. The lower sand is medium to coarse grained and at first yielded as high as 25 barrels in some of the wells, but, like the upper sand, soon fell off and is now practically exhausted. The gravity of the oil in this stratum is about 16° B. Considerable quantities of gas accompanied the oil in the lower sand. Water occurs at a depth of about 900 feet in the neighborhood of Yale and Bernardo streets and in the extreme west end of the field was so abundant as to stop development work in the region south of the Sisters' Hospital.

The two following logs illustrate the strata penetrated in the areas of low and steep dip, respectively, in the productive territory of the eastern field:

Typical well log in the central portion (strata of low dip) of the eastern field, Los Angeles.[a]

	Thickness.	Depth.
	Feet.	*Feet.*
Sandy shale	325	325
Clayey shale, bituminous	55	380
Hard shale	3	383
Clayey shale	12	395
Oil sand (oil 18.75° B.)	55	450
Hard shale	3	453
Tough clay shale	30	483
Hard shale	2	485
Oil sand (oil 16° B.)	25	510
Hard shale	2	512
Tough clay shale	40	552

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[a] Hershey, O. H., Bull. California State Mining Bureau, No. 19, 1900. p. 45.

Typical well log in the eastern portion (strata of steep dip) of the eastern field, Los Angeles.

	Thickness.	Depth.
	Feet.	*Feet.*
Sandy shale with clayey shale toward base	700	700
Oil sand (nearly exhausted when penetrated in 1902)	200	900
Clayey shale	160	1,060
Medium to coarse oil sand (25 barrels oil and considerable gas)	100	1,160
Clayey shale	44	1,204

STRUCTURE.

Pl. XX, sec. G-H, illustrates the probable relations of the beds in the eastern part of the eastern field. The contour lines[a] in Pl. XIX, showing the distance of the upper oil sand below the Los Angeles city datum (255 feet above sea level), also help to make clear the structural features of this district. As would be expected in a region where two important flexures come together at an acute angle, the structure is complex. The flexures referred to are the Elysian Park anticline, which trends N. 60° W., and the anticline and fault along the north side of the oil field, which trend in an approximately east-west direction. As the beds of sandstone and shale in the Elysian Park anticline approach the east-west line of disturbance, they tend to deviate so that their strike is more nearly east and west. Similarly, the beds following the line of the east-west disturbance are inclined to turn so that their trend is somewhat north of west as they approach the thick beds of the Elysian Park anticline. This tendency to change in strike occurs not only in the beds at the surface, but also in the oil sands, as is shown by the contours in Pl. XIX.

The structure in the major part of the eastern field is irregular, the average dip, however, being less than that of the central field. The inclination of the strata appears to be most regular just east of the Sisters' Hospital. From this point almost to Bernardo and Yale streets the dip becomes less and less, but near the latter point it increases abruptly to 50° or more. Toward the east the beds are very much disturbed. Near the corner of Ramona avenue and College street the dip is about 35°. Immediately south of this point is a line of fracture, on the south side of which the strata dip 45°. The conditions beyond the east end of the field are not known because of the lack of surface outcrops and well logs.

The line of disturbance which begins west of Sunset boulevard, northwest of the Sisters' Hospital, and extends almost in a straight line to the corner of Bernardo and Adobe streets, appears to be a very sharp anticline bounded on the north by a fault in which the downthrow is on the south side. In a small cut on the west side of Sunset boulevard, in the axis of this zone of disturbance, the beds dip from 80° N. to 80° S. This has the appearance of an overturn. However, dips obtained in the subway between the Sisters' Hospital and the boiler house and immediately north of the latter show an anticline with dips ranging from 45° S. through horizontal to 45° N. A similar northerly dip is found northeast of the hospital on the corner of Beaudry avenue and the alley between Beaudry and Hinton avenues. These dips occur in thinly laminated yellow sandstone interbedded with minor amounts of arenaceous shale. The anticline, if such it be, is also exposed at the corner of Bernardo and Adobe streets, where the dip ranges from 75° N. through perpendicular to 40° or 50° S. Here, again, the surface evidence indicates an overturn while the well logs suggest a sharp anticline. The productive wells are found, with few exceptions, on the south side of this line of disturbance.

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[a] The lines showing the position of the oil sand in the central and eastern fields are copied from W. L. Watts's map of this field, given in Bull. California State Mining Bureau, No. 19, 1900, fig. D.

As before mentioned, there also appears to be a fault a short distance south of this anticlinal axis, but what relation, if any, it bears to the productiveness of the oil sands is at present unknown. The fault which throws the oil-bearing beds in the field down against the older Puente strata of the Elysian Park anticline is apparently closed so far as escape of the oil is concerned, for no indications of oil or asphaltum have yet been discovered along its trace. The sealing of the north end of the truncated oil sands by the impervious material of this fault zone may account in a measure for the retention of the oil.

In the vicinity of Chavez Ravine, and immediately north of the main east-west fault, which limits the productive territory of the eastern field on the north, the strata strike N. 80° W., with dips varying from 20° to 30°. A disturbance affects the beds, however, at the corner of Elysian Park avenue and Innes street, just north of Reservoir Hill, where they dip in a northwesterly direction, although the dips all around this point are uniformly toward the south or southwest.

The territory between the eastern and central fields is considerably broken up and, as reported by the drillers, contains much water and little oil. This condition is doubtless due to a zone of disturbance which branches off from or is a continuation of the fault at the corner of Sunset boulevard and Sutherland street, and which extends from this point in a general south-southeasterly direction past the corner of Sunset boulevard and Innes street toward the Sisters' Hospital. The character of this line of disturbance has not been determined, but it appears quite probable that it is a fault zone, with the downthrow on the east.

DEVELOPMENT.

The first well drilled in the eastern field was sunk at the corner of Adobe and College streets in November, 1896. From the time this well was found to be successful until the latter part of 1897 development went on rapidly until nearly the whole of the productive territory was exploited. Since 1897 few wells have been put down, while a number of those which at one time produced considerable quantities of oil have become exhausted and have been abandoned. There are at present (February, 1906) 270 wells in the field, of which 211 are pumping and 59 are either not pumping or are abandoned. The wells vary in depth from 500 to more than 1,200 feet and yield from 1 to 12 barrels of oil per day. Some of the wells are said to have yielded as high as 50 or 60 barrels at their inception, but these were unusual. In addition to oil the wells produce more or less gas. The oil is black and varies in gravity from 16° to 19° B., the lighter oil coming, it is said, from the higher sand.

CENTRAL FIELD.

LOCATION.

The central field occupies the territory lying between the Sisters' Hospital, corner of Sunset boulevard and Beaudry avenue, on the east, and Coronado street, one-fourth mile north of Westlake Park, on the west. Its northern boundary is an almost straight east-west line drawn from the middle of the west side of the hospital grounds to a point on Coronado street about 100 yards north of Ocean View avenue; its southern boundary is Ocean View avenue from Coronado street east to Arnold street, thence a line east to the corner of First and Lucas streets, thence a line to the corner of Temple street and Beaudry avenue, and finally Beaudry avenue from Temple street to Sunset boulevard. The productive territory is about 1½ miles long, 1,000 feet wide near its east end, and 300 feet near its west end. The total area is approximately nine-twentieths of a square mile. Like the eastern field, the central is a narrow band through one of the thickly populated residence districts of the city, the wells in many cases being put down in close proximity to houses and store buildings.

TOPOGRAPHY.

Northwest of the business portion of Los Angeles and east and northeast of Westlake Park is a tableland or terrace lying at an elevation of about 100 to 150 feet higher than the main portion of the city. This table-land is bounded on the north and west by a ravine extending southwestward from a point immediately west of the north end of Echo Lake and is bisected by a narrow valley which contains Echo Lake and extends south-southwestward toward the business center. In addition to these, several small ravines drain toward the southwest from the top of the terrace. The central field occupies the top of the terrace immediately south of the ravine first mentioned, extends eastward across the table-land to the Echo Lake valley, down into and across this depression and up again on to the terrace, and thence across it to the eastern limit of the field at the Sisters' Hospital.

GEOLOGY.

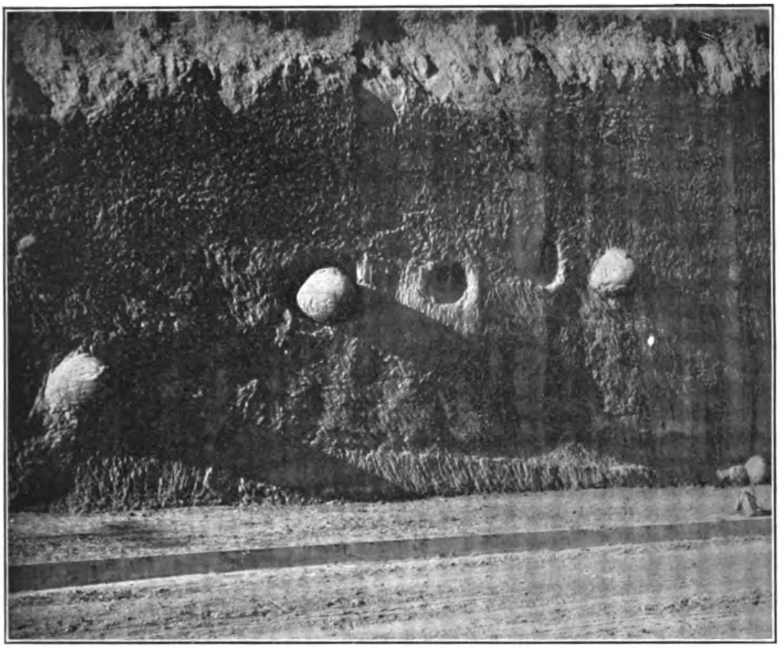
The formations involved in the geology of the region immediately adjacent to the central field comprise the upper portion of the Puente formation, with its two bands of white siliceous shale and the intervening sandstone layer, and the soft sandstone and sandy shale of the Fernando. There is also a more or less persistent layer of Pleistocene gravel, which caps the upturned edges of the older beds over portions of the terrace.

The sandstone between the two white-shale layers, which is the principal oil sand in this as well as in the eastern field, consists of about 150 feet of coarse yellow arkose sandstone in layers 3 to 24 inches thick, interbedded with minor quantities of fine gray shale. Good exposures of this sandstone are found on Court street immediately west of Lake Shore avenue and also on Burlington avenue a short distance north of First street. In the region directly north of Westlake Park the color of this same band, which here approaches a grit in certain layers, varies from chocolate and purplish gray to brown. The discoloration is doubtless due to the petroleum which the sands at one time contained. Similar colors were noted in sands which are supposed to be stratigraphically equivalent on Sunset boulevard northwest of Echo Lake. (See Pl. XXI, *A*.)

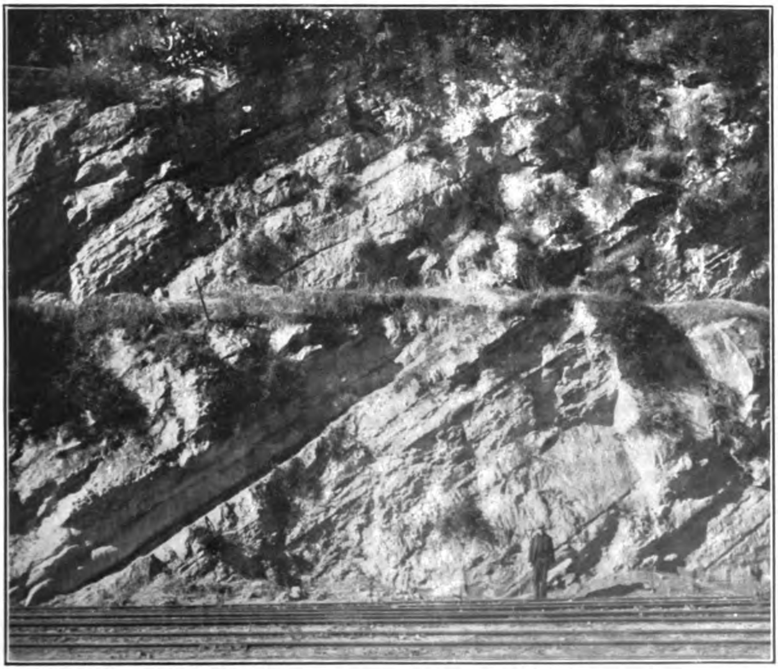
Interbedded with the thin white shale which underlies the sandstone are darker, softer shale and fine sandstone which locally appear to be petroliferous. A cut in First street west of Burtz street offers a good exposure of this oil-bearing shale. These beds occupy the hilly country north of the central field, lying in low folds with dips that vary from horizontal to 10° or 15° and showing no continuous lines of structure. As indicated by well records, they carry traces of petroleum as far east and north as the region immediately northwest of Echo Lake, but the accumulations are not of economic importance, as they are in the same beds northwest of Coronado street in the western field.

The band of white shale above the main oil sand already described is not over 50 feet thick, but owing to the resistant qualities of the thin flinty laminæ of which it is composed it can be more easily traced along its surface outcrop than any other stratum in the region. Angular fragments of thin shale strew the surface of the ground throughout the greater part of the distance from Lake Shore avenue westward to a point 1½ miles southeast of Colegrove. If it were not for this hard, flinty shale the difficulty of tracing the continuity of the formations north of the central field would be greatly increased.

Above this flinty shale band lie the soft conglomerate, heavy and thin-bedded fine-grained sandstone, and sandy and clayey shale of the Fernando. This formation is probably over 2,000 feet thick, only the lower part, however, being exposed in the central field. In this field the soft, thin-bedded sandstone is confined largely to the lower 500 feet of the formation. This sandstone appears to be more or less petroliferous toward the west end of the field, and as a consequence its outcrop is stained rusty red, purple, and pink. This coloration of



A. NODULAR MIOCENE SANDSTONE AT LOS ANGELES.



B. TYPICAL LOWER MIOCENE SANDSTONE AT LOS ANGELES

the beds is particularly noticeable along Ocean View avenue west of Alvarado street. Toward the east end of the field the sandstone is usually light to dark yellowish brown. Above the soft sandstone and sandy shale is a zone of fine-grained shale, several hundred feet in thickness. Some of this shale is hard and appears to be more or less calcareous. Veins of gypsum are abundant in this part of the formation. Excellent exposures of this fine-grained shale are found on Beaudry avenue near Fourth street and in many road cuts both northeast and west of this locality.

The uppermost beds of the Fernando exposed in Los Angeles lie south of the central field, occupying the ridge on which the State Normal School is located. These are soft clayey shales and heavy-bedded, fine, light-colored sandstone with some interstratified conglomerates. The fossils listed on page 153 came from these beds in the region south of the central field.

GEOLOGY OF THE WELLS.

As indicated by the well logs, the underground geology varies somewhat throughout the extent of the central field. The southerly dip of all the beds, however, is common from one extremity of the field to the other. The strata in general are less disturbed and dip at lower angles in the east end of the field, and the oil sand on that account appears thinner in that region. In the territory east of Belmont avenue most of the wells penetrate sandy and clayey shale (Fernando) for the first 500 or 600 feet. Beneath this is the oil sand, consisting of 125 feet of thick layers of coarse arkose material interbedded with thin clayey shale. About 200 feet beneath this sand is the lower productive zone, which consists of 40 to 50 feet of medium to coarse sand in layers similar to those of the upper zone. The two oil-bearing beds are separated in the northern part of the field by about 200 feet of tough blue clay, but toward the south this thins out and the productive sands tend to coalesce. On the south edge of the field the rocks below a depth of 950 feet consist of alternating clayey and coarse sandy layers, which replace the heavy, well-defined 10 to 15 foot sands farther north. The gas pressure is stronger and the oil more abundant, heavier, and redder along the south edge of the field than in the same beds nearer the surface in the northern portion. This reddish oil, it is said, gradually turns black on exposure to the air. Below the lower productive zone is 15 to 20 feet of clayey shale and thin-bedded sandstone carrying considerable quantities of water. The south edge of the field is defined by the line where this water becomes so abundant that it completely hinders development. The water level is said to be between 900 and 950 feet below the surface east of Belmont avenue and 1,050 feet west of it.

The following is a characteristic well log from the northern part of the central field:

Log of well two blocks east of Lake Shore avenue, Los Angeles.

[Elevation approximately 400 feet above sea level.]

	Thickness.	Depth.
	Feet.	*Feet.*
Alternating blue clayey shale and fine soft sandstone	600	600
Same, with oil seepages in sandstone	40	640
Blue clayey shale	60	700
Coarse oil sand	70	770
Blue clayey shale, with sandy layers containing oil	180	950
Medium to coarse oil sand	50	1,000
Blue clayey shale	10+	1,010+

The following log is characteristic of the region about Second Street Park, immediately east of Lake Shore avenue, the well being two blocks southwest of that whose log has just been given:

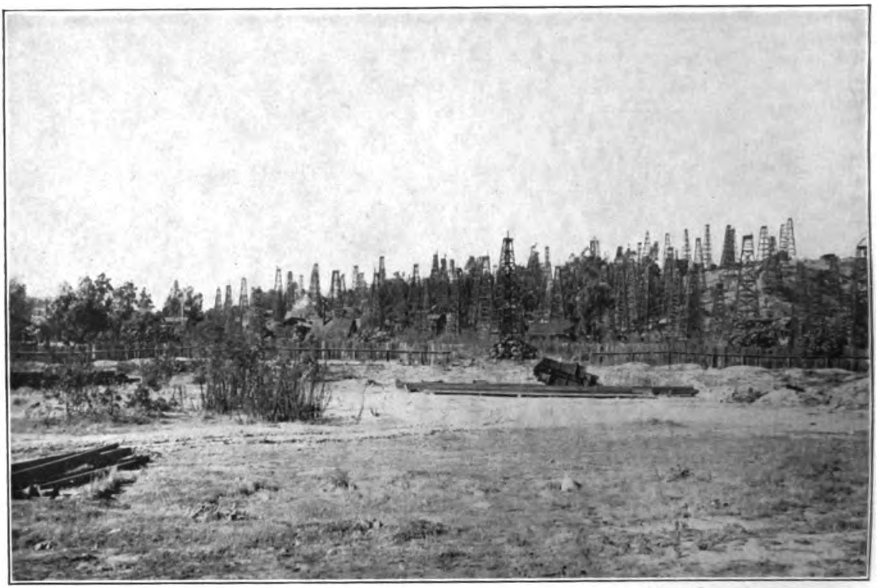
Log of well in Second Street Park, near Lake Shore avenue, Los Angeles.[a]

[Elevation approximately 325 feet above sea level.]

	Thickness.	Depth.
	Feet.	*Feet.*
Sandy and clayey strata with thin strata of hard rock ("shells")	650	650
Oil sand interstratified with sandy clay	125	775
Tough clay ("putty")	200	975
Oil sand. with water	3	978
Sand with water.		

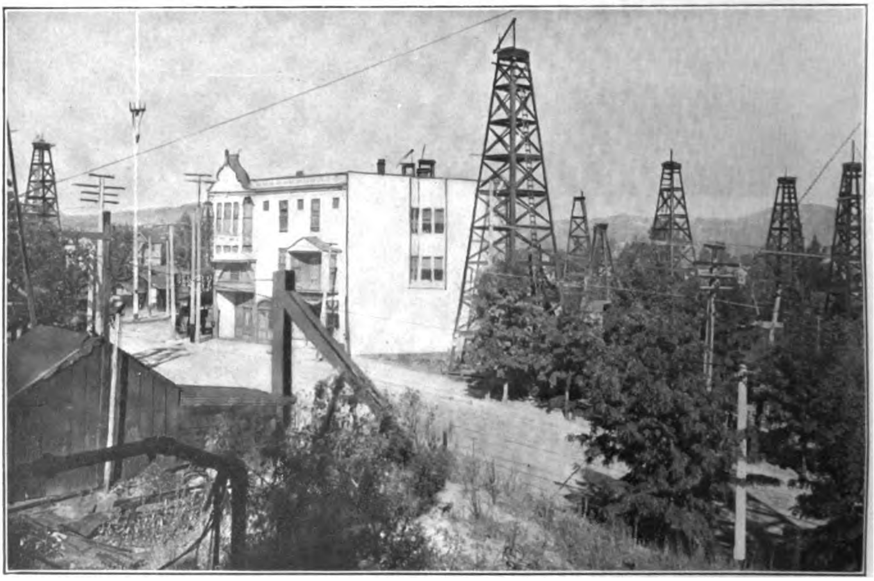
[a] Watts, W. L., Bull. California State Mining Bureau, No. 11, 1897, p. 6.

West of Belmont avenue the dip becomes steeper, and although the water line becomes lower, and the wells consequently can go deeper, the field narrows appreciably. Between Burlington avenue and Alvarado street the productive territory is about 600 feet wide; west of Alvarado street it narrows to 500 feet, and at the end of the field, near Coronado street, to about 300 feet. Near the corner of Belmont avenue and First street the wells penetrate soft fine sandstone and sandy and clayey shale for the first 850 feet, below which they pass into a 50-foot zone of clayey shale, in which are interbedded petroliferous sandy beds called "stray" sands by the drillers. The oil sand is struck at about 900 feet and is 100 feet thick, the dip here being between 30° and 40°. At 1,040 feet there is a 70-foot sand, which grades below into a white sand bearing salt water. This constitutes the lower limit of the productive zone.



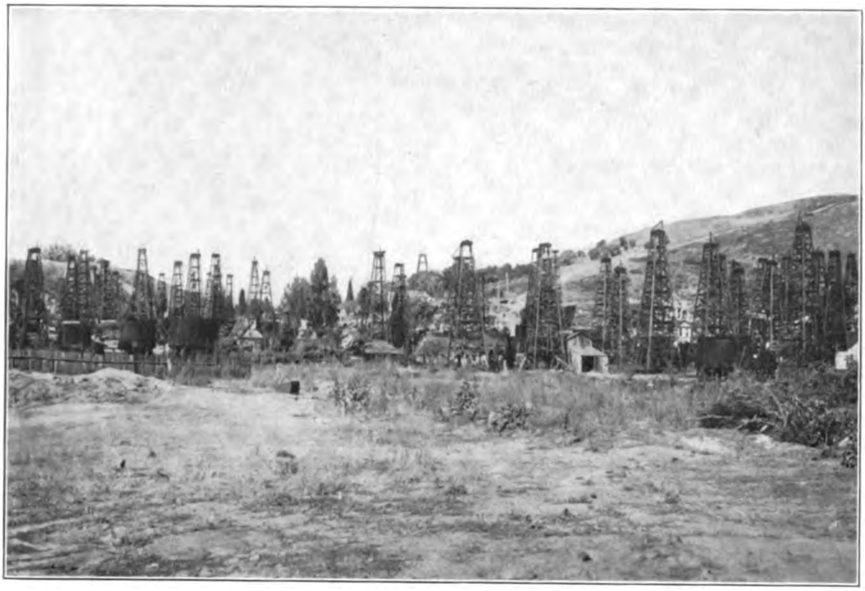
A. EASTERN OIL F

Looking north fro



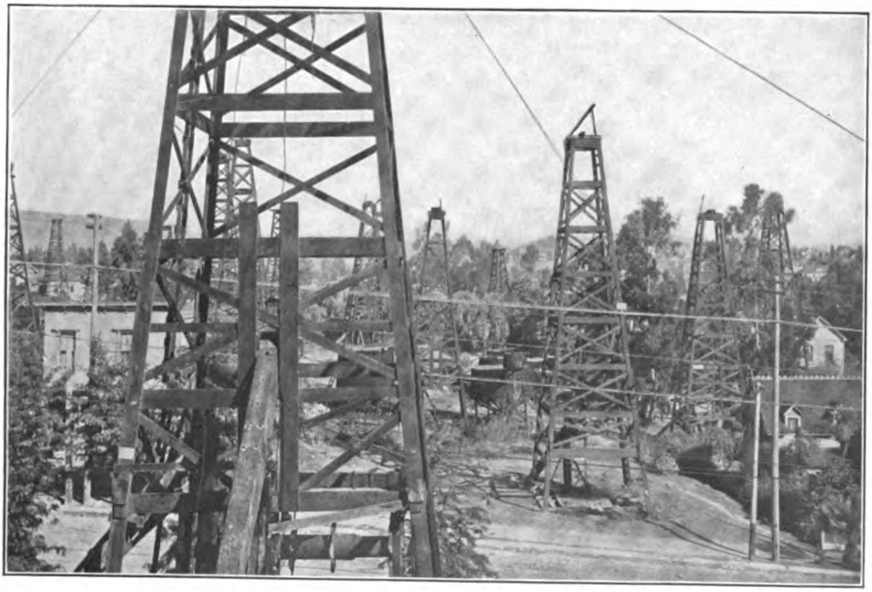
B. CENTRAL OIL FIE

Looking east from near corner of F



ELD, LOS ANGELES.

Baker Iron works.



ELD, LOS ANGELES.

irst street and Belmont avenue.

A typical log for the part of the central field lying near Belmont avenue is as follows:

Log of well at corner of Belmont avenue and First street, Los Angeles.

[Elevation approximately 400 feet above sea level.]

	Thickness.	Depth.
	Feet.	*Feet.*
Clayey and sandy shale	850	850
Clayey shale with interbedded oil producing sand ("stray" sand)	50	900
Good oil sand, medium to coarse	100	1,000
Clayey shale	40	1,040
Oil sand	70	1,110
White sand with salt water	10+	1,120+

In the region between Burlington avenue and Alvarado street the dip is steep, the oil sand being struck at about 700 feet on the north side of the productive belt, 900 feet in the middle, and 1,100 feet at the south edge. The strata above the oil sand consist largely of dark-colored shale and thin-bedded sandy layers, the latter occasionally petroliferous or water bearing toward the base of the section. Owing to the steep dip in this part of the field, the wells remain in the oil sand for a much greater distance than they do farther east. There are also indications of a tendency toward coalescence of the oil sands here, caused by a partial pinching out of the shale beds. One well near the north side was drilled for over 300 feet through productive sand, with only a few thin layers of shale. The water plane in this portion of the field appears to be almost level, being struck at a depth of about 1,200 feet on the north side and 1,250 feet on the south side. The water is salt, and displaces the oil in the sandy beds below these depths.

From Alvarado street westward to the end of the field the beds dip at angles varying from 50° to 70°, and the width of the field is reduced to a minimum of 300 feet. The strata are practically the same as those penetrated east of Alvarado street, the only difference being that the water plane is a little lower—at a depth of about 1,300 feet—and the wells are in consequence a little deeper. The wells here are said to be the most productive in the field, some of them having yielded 60 barrels a day at the start and kept up a steady production of 20 barrels for at least a year. Owing to the steepness of dip and the close proximity of the wells to the structural disturbance at the bend in strike, which occurs only a short distance west of the west end of the field, considerable difficulty is experienced from caving. Toward the northern edge of the field the wells go to 1,200 feet and obtain good results, but much water is encountered in many of the beds above the 700-foot level. At the south edge of the field the productive zone, which extends from a depth of 1,000 or 1,100 feet to the water plane at 1,300 feet, consists of clayey shale interstratified with oil-bearing "stray" sands.

STRUCTURE.

The most important structural feature in the central field is a line of disturbance which extends from the region 100 feet or so north of the corner of Patton and Temple streets westward to a point on Benton street about 200 feet south of First. (See Pl. XX, sec. E–F.) Near this last point it bends and passes to the northwest toward Colegroove. This structural feature is in alignment with the fault along the north side of the eastern field, and is probably a continuation of it. In fact, the only stretch of territory over which it can not actually be traced is that lying between the corner of Sumner place and Bellevue avenue, northwest of the Sisters' Hospital, and a point north of Temple street near Patton. Throughout this stretch and north and south of it for some distance the beds all dip to the south at angles varying from 8° to 35°, and no evidences of folding or important faulting were observed.

The anticlinal structure of the flexure is attested by the fact that the beds dip to the south on Court street near Lake Shore avenue and to the north two blocks farther north. The more or less irregular position of the beds in the axis of this anticline near the corner of Temple street and Lake Shore avenue indicates that considerable faulting accompanied the folding. The exposures on Sumner place between Sunset boulevard and Bellevue avenue, in the region northwest of the corner of Patton and Temple streets, on Burlington avenue 200 feet or so south of Temple, and on Benton street about 200 feet south of First offer further evidence in favor of the fault theory.

The southern or productive limb of the anticline, although much the steeper, shows more regularity throughout the central field than the northern limb. It is considerably broken and irregular at its east and west ends, but these conditions are probably due to other lines of disturbance crossing its strike. The dips near the axis of the anticline are usually low, becoming steeper toward the south. The oil appears to accumulate in the steeper beds just below the point where they bend to the lesser dips near the axis. This is well shown in fig. 13, a section along C–F, Pl. XVIII, across the field near Lake Shore avenue. The dips in the southern limb of the anticline in the east end of the field vary from 10° to 45°, becoming abruptly steeper toward the east end and reaching a maximum of 70° near the corner of Bellevue avenue and Victor street, just west of the Sisters' Hospital. This marked change in the dip is doubtless in some way related to the line of disturbance described in discussing the structure of the eastern field (pp. 163–164) as extending southward from the corner of Sunset boulevard and Sutherland street toward the Sisters' Hospital. To the west of Belmont avenue the dips become steeper, some of them being 70° or more, and the breadth of the field decreases in a corresponding manner. The productive area is locally interrupted in the region immediately west of Coronado street, by the fractures attending the change in the direction of the strike of the beds.

A line of minor faults, some normal, others reverse or thrust, is developed on the south flank of the major flexure. A normal fault occurs on Welcome street 150 feet south of Council, and an excellent example of the thrust faults is shown about 25 feet north of Colton street on the west side of Lake Shore avenue. This secondary line of disturbance seems to mark practically the northern limit of the productive territory over a considerable portion of the field, but it is problematical whether this is merely a coincidence of position—the productiveness of the sands depending on their distance from the axis of the anticline or their depth below the surface, or both—or whether the minor faults really seal the upper ends of the oil-bearing beds and thus limit the field. The fact that a few productive wells are found north of the line of faulting offers evidence refuting the absolute effectiveness of the barrier even though it is operative over a portion of the territory, unless the explanation is that these wells pass through the tilted fault plane and derive their oil from the productive beds below and to the south of it.

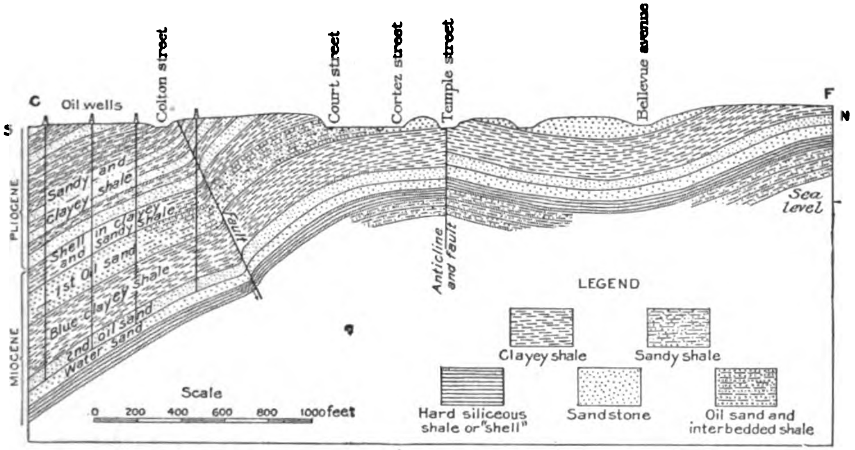


FIG. 13.—North-south section across the central field on the line C–F, Pls. XVIII, XIX, along the western side of Lake Shore avenue, Los Angeles.

North of the main line of disturbance the beds for the most part show local flexures with low dip; these apparently bear little relation to the major structural features or to each other. The general anticlinal structure of the major flexure described in the preceding paragraphs is evidenced, however, by the recurrence in two knolls, cut through by Sunset boulevard northwest of Echo Lake, of the coarse sandstone (oil sands) found south of the axis in immediate proximity to the northern boundary of the central field.

DEVELOPMENT.

The central is the oldest field in the Los Angeles district, its first productive well having been sunk in 1892. As soon as oil was assured other wells were drilled in the immediate vicinity, and the field grew rapidly. The development of that part of the field lying east of First street was practically complete by the end of 1896, while most of the wells in the western part were sunk during the period from 1897 to 1900. There are at present (February, 1906) 516 wells in the central field, of which 206, or about 40 per cent, are pumping, while 310, or about 60 per cent, are either abandoned or not pumping. In the region west of Bonnie Brae street the proportion of pumping wells is 60 per cent, but in the eastern part of the field it is only 31 per cent. This is doubtless due to the greater age of the eastern wells. The wells vary in depth from 500 to 1,400 feet, averaging deeper in the western than in the eastern part. The eastern wells now produce from 2 to 8 barrels per day, and the western wells go considerably higher, some possibly to 12 or 15 barrels. The average for the field is said to be about 4 barrels. At their inception some of the wells in the western part of the field gave 60 barrels per day, but soon fell off to 20 barrels. The gravity of the oil in this field varies from 14° to 16° B.

WESTERN FIELD.

LOCATION.

The western field includes all of the oil-producing territory lying to the west and northwest of Coronado street, north of Westlake Park, with the exception of the area described on pages 186–195 as the Salt Lake field. In its restricted sense the western field is a belt trending N. 70° W., about one-half mile wide at its southeast end and one-fourth mile wide at its western terminus southeast of Colegrove. Within this area of about 1½ square miles are four rather distinct groups of wells, the area covered by them being something less than one-half the total area of the oil-yielding belt.

TOPOGRAPHY.

The region of the western field, viewed topographically, is one of transition from the pronounced hilly country northwest of Elysian Park to the broad, gently southward-dipping Los Angeles-Santa Monica plain. Its characteristic features are low rolling hills, separated by more or less strongly pronounced ravines, which run in a southerly or southwesterly direction.

GEOLOGY.

Superficial Pleistocene deposits cover a large part of the western field, but from the examination of exposures along the ravines in its eastern part and from a study of the well logs it is known that the formations underlying it are the same as those exposed in the eastern and central fields. These are the lower Puente sandstones, the Puente shale and thin-bedded sandstone, the Fernando sandstone, and the Pleistocene gravel, sand, and clay.

The most prominent bed exposed is the coarse sandstone which lies between the bands of hard, white, thin-bedded shale at the top of the Puente formation. Exposures of this sandstone may be traced from the hill one-half mile north of Westlake Park to the bend in the Hollywood and Cahuenga Valley Railroad at the corner of Western avenue and Temple road. The exposures one-half mile north of Westlake Park show a medium to coarse or rather gritty sandstone, with colors varying from light yellow and brown to chocolate, gray, and dark brown. The beds are considerably disturbed, being near the point of change of strike from N. 80° W. to N. 65°–70° N. West of this locality, toward the Baptist College, the sandstone outcrops along the face of the hill east of Occidental boulevard. Still farther west, at the corner of Commonwealth avenue and Geneva street, the sandstone dips 20° S. 20° W. and is interbedded toward the top with some thin layers of hard siliceous shale. Immediately southwest of the Baptist College the same sandstone, highly impregnated with oil, in layers from 12 to 36 inches thick, has a dip of 20° S. At this point the sandstone is coarse and chocolate colored, and is interbedded with 1- to 12-inch layers of chocolate-colored shale, which contains large quantities of carbonaceous matter and some sulphur.

Immediately north of the Baptist College are some exposures of white thin-bedded shale, interbedded with softer, darker-colored shale which dips toward the south, under the coarse sandstone. This shale continues toward the northwest and is exposed in a much crumpled condition on First street about one block east of Vermont avenue. It also occurs in a small ravine near the junction of Rosedale avenue and the Hollywood and Cahuenga Valley Railroad. The last good exposure is found on Western avenue, just north of Temple road. Interbedded in the shale about 300 feet stratigraphically below the main layer of coarse sandstone, is a band of somewhat similar sandstone which appears to be the principal productive bed in the western field. This lower sand is well shown in a cut on the Hollywood and Cahuenga Valley Railroad at Vermont avenue. The dip here is 10° due west. The sandstone looks very much like that exposed on Sunset boulevard and has similar large ellipsoidal concretions. It does not appear to contain any prominent shale layers, although it is overlain and underlain by the thin white siliceous beds. As exposed in this railroad cut the sand is about 50 feet thick, but the records of wells in other parts of the field show that it varies considerably in thickness and also in the number and prominence of the included shale layers.

Above the upper coarse sandstone are some layers of thin-bedded white shale, which may be traced westward from the region immediately north of Westlake Park toward the corner of Fifth and Hoover streets, and thence northwestward across Vermont avenue to Western avenue, which it crosses about one-fourth of a mile south of Temple road. This shale, according to the well records in the region southwest of the corner of Western avenue and Temple road, probably averages somewhat thicker in the western field than it does in the central.

The Fernando is represented in the western field by rather hard gray to chocolate-colored shale, exposed on a small creek southwest of the Baptist College. The beds dip 22° S. 25° W. Some soft, thin-bedded sandstone and sandy shale also occur in the formation above the hard beds near the base. Although there are few outcrops to corroborate the assertion, it is exceedingly probable that the Fernando overlies the Puente over the whole extent of the Los Angeles-Santa Monica plain, south of Temple road and at least as far west as the west end of Rancho la Brea.

As previously stated, the Pleistocene deposits consist of gravel, sand, and clay and lie unconformably upon the older rocks from the foot of the Santa Monica Mountains southward across the Los Angeles-Santa Monica plain. An excellent exposure of the Pleistocene occurs in the ravine northwest of the Baptist College. This deposit consists of sand and gravel of granitic quartz, sandstone, and shale fragments, some of the cobbles attaining a diameter of over 6 inches. The whole is richly impregnated with heavy oil, which seeps from the underlying sandstone and shale and imparts a dark chocolate color to the mass. Pleistocene deposits, consisting of roughly bedded sand and gravel, lying in an approximately horizontal position, may also be seen in cuts along some of the roads west of Hoover street.

GEOLOGY OF THE WELLS.

For convenience of discussion, the western field will be divided into four areas corresponding to the four more or less distinct groups of wells which it comprises. The first area—the largest and by far the most important—embraces the territory in the vicinity of the Baptist College, and is bounded by Coronado street on the southeast and by Rosedale avenue on the west; the second area includes the region about the bend in the Hollywood and Cahuenga Valley Railroad at the corner of Western avenue and Temple road; the third is located two or three blocks northwest of the second; and the fourth covers a few acres at the east end of the Rancho la Brea about a mile south of Colegrove.

BAPTIST COLLEGE AREA.

A reference to the geologic map (Pl. XVIII) will show that within the Baptist College area are the outcrops of five distinct zones, which are, from the base up, the oil-bearing thin-bedded shale and sandstone of the Puente formation, southwest of these the 150-foot oil sand of the central field, the white-shale zone at the top of the Puente, the thin-bedded sandstone of the Fernando, and over all in more or less scattered patches the Pleistocene gravel and sand. Oil is derived principally from a zone (probably corresponding with the lower oil zone of the central field) of interbedded clayey shale, "shell," and oil sands, the top of which lies from 200 to 400 feet below the bottom of the main oil sand of the Los Angeles district. As would be expected, the logs of the wells in this area farthest toward the southwest give the most complete records. The Fernando formation consists of sandy shale and fine sandstone, beneath which are the clayey shale and interbedded "shell" layers which lie above the thickest sandstone bed. This sandstone bed (first oil sand), where reached by wells south of its outcrop, usually gives a small yield of heavy oil. Below the sandstone the wells penetrate about 400 feet of thin-bedded blue clayey shale, thin hard "shell," and interbedded oil-bearing sands. Between 130 and 170 feet above the bottom of this shale is a layer of coarse, water-bearing sand, and at its base is a 20 to 50 foot oil sand, the greater thickness in wells in the southwestern part of the area, the less in the wells which start down north of First street. From this horizon down the well logs show considerable discrepancy. Blue clayey shale,

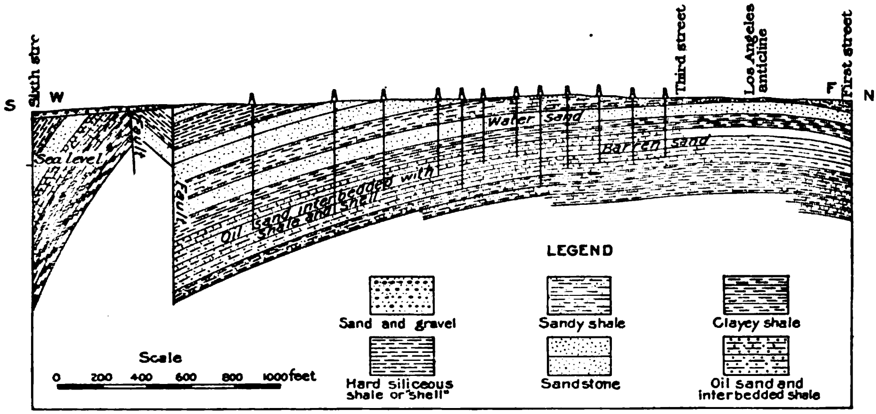


FIG. 14.—North-south section on the line W-F, Pls. XVIII, XIX, along Hoover street from First to Sixth streets, Los Angeles, showing the structure of the western field.

containing thin to moderately thick beds of oil sand with some water-bearing strata between appears to lie beneath the lower or second oil sand in most of the wells. Water with a temperature of 104° was struck in a well at the corner of First street and Vermont avenue at a depth of 800 feet. In this well from 800 down to 1,735 feet the strata are blue clayey shale and some "shell." A heavy flow of water was encountered at 1,400 feet. The sandy shale from 1,400 to 1,735 feet yielded some oil and gas. The record of a well drilled immediately southwest of the corner of Fourth and Hoover streets reveals some interesting facts. The first oil sand in this well (probably the second of the above discussion) was encountered at 250 feet and extended to 350 feet. This productive sand, as reported, was succeeded below by water-bearing sand, with no shale or other parting between. When the depth of 350 feet was reached the well yielded from 75 to 100 barrels of oil containing no water for a time, but finally water came from below and the well was temporarily abandoned. After it had lain idle for five or six months operations were again begun, but the moment the water in the well was agitated the strong gas pressure threw water and oil 30 or 40 feet into the air. Drilling was recommenced after this spasmodic "gush," but water-bearing sands and some shale were the only strata penetrated to 1,000 feet, where a 6-foot layer of coarse bowlders was encountered. From 1,000 feet down the formation was clayey shale, with a 20-foot oil sand between 1,100 and 1,200 feet and another 50-foot sand between 1,300 and 1,400 feet. These sands were very productive, but owing to the softness of the beds the water could not be shut off and was always troublesome.

In the territory southwest of the corner of Sixth and Hoover streets the wells start down in the beds overlying the first oil sand (here almost barren), penetrate the sand for about 150 feet, pass through 300 to 400 feet of clayey and sandy shale and reach the second or productive sand, from 60 to 90 feet thick, at a depth of about 525 feet. North-northeast of this locality, in the region about the corner of Hoover and Geneva streets, the second sand (the first encountered in these wells) is struck at about 190 feet and is 22 feet thick. About 50 or 60 feet below this sand is another 60-foot productive zone. The same relative conditions as have just been described exist along the strike of the beds toward the northwest, the shallow wells, varying in depth from 140 to 400 feet, occurring in the northeastern portion of the field, while the deeper wells are found along the southwestern border.

The oil in many of the wells in the Baptist College area has been succeeded by water, which appears to follow up the oil from below. There is also more or less water in all the producing wells, some, it is said, yielding 75 barrels of water for each 25 barrels of oil. Gas occurs in most of the wells, but not in sufficient quantities to be of economic importance. The oil is mostly black, but the emulsion of oil and water as it is pumped from the wells usually appears bronze colored. Some of the wells near the corner of Dome and Hoover streets, high up on the rise of the oil sands and not far from the axis of the anticline, yield red oil, which, however, becomes black on exposure to the air. The gravity of the oil in the Baptist College area varies from 12.5° to 14.5° B. The production is from a fraction of a barrel to 5 or 6 barrels per day. Some of the wells are said to have started with a production of 75 to 100 barrels but fell off to 30 barrels after ten months, 3 barrels after two years, and 1½ barrels after three years. The effect of the new wells on the old was imperceptible, the decrease in production being due to a local sapping of the sand immediately surrounding the well.

The three following logs are characteristic for their respective localities:

Log of well immediately southwest of the corner of Hoover and Fourth streets, Los Angeles.

[Elevation approximately 275 feet above sea level.]

	Thickness.	Depth.
	Feet.	*Feet.*
Coarse sand, with clayey and sandy shale and occasional thin "shell" layers toward the base	250	250
Excellent oil sand, yielding 75 to 100 barrels of oil at start	100	350
Alternating thin-bedded sandstone and shale containing water	650	1,000
Layer of coarse conglomerate ("bowlders")	6	1,006
Alternating thin-bedded sandstone and shale, with water	94	1,100
Good oil sand; some water	20	1,120
Clayey shale	180	1,300
Good oil sand; some water	50	1,350
Soft clayey shale, too soft to hold casing for shutting off water	80	1,430

Log of well immediately northeast of the corner of Hoover and Geneva streets, Los Angeles.

[Elevation approximately 290 feet above sea level.]

	Thickness.	Depth.
	Feet.	*Feet.*
Brown clayey shale	60	60
Coarse sand and water	130	190
Oil sand	22	212
Very hard "shell"	3	215
Barren oil sand	55	270
Oil sand	58	328

Log of well southeast of the corner of Vermont avenue and First street, Los Angeles.

[Elevation 260 feet above sea level.]

	Thickness.	Depth.
	Feet.	*Feet.*
Hard sandstone	80	80
Blue clayey shale alternating with thin oil sands	400	480
Oil sand, also containing little water under pressure	20	500
Blue clayey shale and thin sandstone, some of latter oil bearing; water sands between oil sands	300	800
Sandstone containing hot water, 104° F	2	802
Oil sand containing light oil	28	830
Sandstone containing water	5	835
Clayey shale	15	850
"Marble" (calcareous scale or "shell")	3	853
Alternating blue clayey shale and medium- to fine-grained, thin-bedded sandstone	547	1,400
Heavy flow of water in sand	1+	1,401
Sandstone and light oil strata with gas all the way down	334	1,735

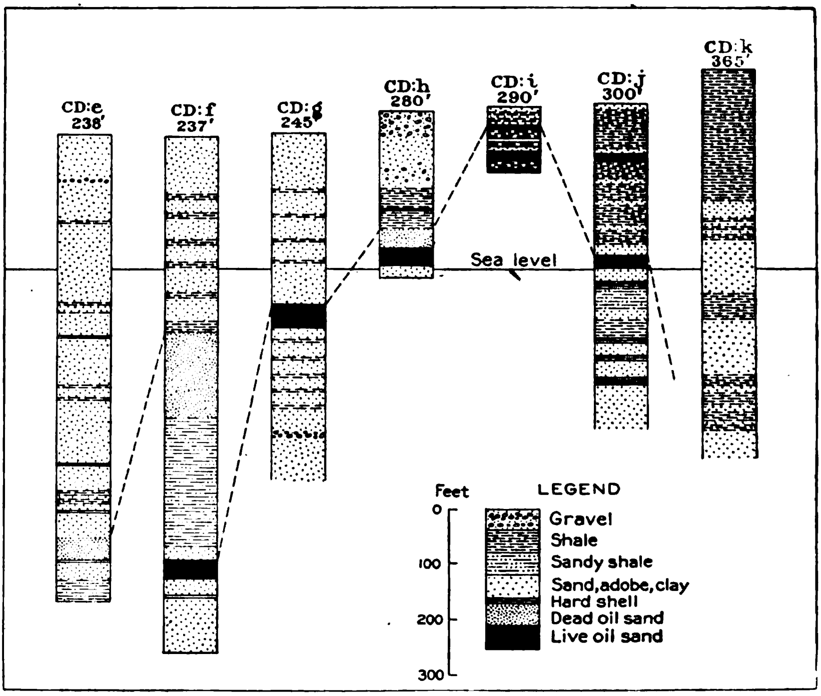


FIG. 15.—Detail of section along the line C-D, Pls. XVIII, XIX, western oil field. Small letters refer to locations of wells on section C-D, Pl. XX.

VICINITY OF WESTERN AVENUE AND TEMPLE ROAD.

The formations underlying the area east of the corner of Western avenue and Temple road are the same as those found toward the southeast, in the region of the Baptist College. The surface outcrops seem to indicate that the dip of the beds is toward the southwest, but from the evidence offered by a group of wells just south of Temple road one-fourth mile east of Western avenue, the dip appears to be south-southeastward about 4 feet in 300 feet. This discrepancy is doubtless due to the proximity of the area to the axis of the Los Angeles anticline.

The wells in the northern part of the area, near Temple road, after penetrating gravel and sand for approximately 100 feet pass through alternating clayey shale and fine sandstone for about 250 feet. At this depth the oil sand, which appears to be barren at the top but productive below, is encountered and extends for 35 feet. About 20 feet below this is a layer of sand which yields flowing water. The wells in this part of the area yield an average of 1 to 2 barrels of 15° B. oil per day; and in addition considerable quantities of gas and usually less than 2 per cent of water.

About one-fourth mile to the southwest down the dip from the territory just described the wells reach the oil sand at 310 feet. The sand is here 40 feet thick and is somewhat more productive than it is higher up, yielding on an average 6 barrels per day per well. The same strata were penetrated and the same amount of water is encountered in these deeper wells as in the wells to the northeast.

Still farther southwest, about one-half mile southwest of the corner of Western avenue and Temple road, the wells strike an oil sand at a depth of about 350 feet which outcrops at the surface in the vicinity of the wells just described. This sand furnishes the main yield of these wells. About 350 feet below this upper oil sand is encountered a second oil zone corresponding to the productive sand of the wells half a mile to the northeast. The strata above the first sand are largely clayey and sandy gray shale, possibly Fernando in part, with some harder shale and "shell" layers immediately above them. Between the first and second oil zones are alternating clayey and sandy shale with a few thin layers of hard siliceous shale or "shell;" isolated accumulations of oil and gas occur throughout these beds.

The three following well logs are characteristic of the region near Western avenue:

Log of well one-fourth mile east of the corner of Temple road and Western avenue, Los Angeles.

[Elevation, 280 feet above sea level.]

	Thickness.	Depth.
	Feet.	*Feet.*
Gravel and bowlders	45	45
Coarse white sand	30	75
Red gravel	20	95
Small pebbles	20	115
Soft sandstone	12	127
Hard sandstone	6	133
Hard light-yellow shale	15	148
Hard black shale	17	165
"Shell" or hard white siliceous shale	3	168
Black shale	38	206
"Dead" oil sand	35	241
"Live" oil sand	35	276
Black shale underlain by stratum of artesian water	20	296

Log of well one-fourth mile east-southeast of the corner of Temple road and Western avenue, Los Angeles.

[Elevation, 245 feet above sea level.]

	Thickness.	Depth.
	Feet.	*Feet.*
Soil	50	50
"Adobe" or sandy shale	20	70
Yellow clay	20	90
"Adobe"	10	100
Sand and shale	135	235
"Adobe"	75	310
Oil sand	40	350
Thin-bedded clayey shale and sand; artesian water at 390 feet	40	390
Thin-bedded clayey shale and sand	70	460
Clayey shale; artesian water in fine white sand at 470 feet	10	470
Clayey and sandy shale and fine sandstone	30	500
Same as last, with artesian water in quicksand	40	540
Conglomerate	10	550
Sandy shale	5	555
Hard white sandstone	70	625

Log of well one-half mile southwest of the corner of Temple road and Western avenue, Los Angeles.

[Elevation, 238 feet above sea level.]

	Thickness.	Depth.
	Feet.	*Depth.*
Red gravel and sand	40	40
Water sand	8	48
Blue clayey shale	4	52
Gray clayey shale	22	74
Blue sand	23	97
Gray clayey shale	9	106
Hard sandstone	1	107
Gray clayey shale	27	134
Hard shale	1	135
Hard sandstone and clayey shale	14	149
Hard shale	2	151
Hard sandstone and clayey shale	30	181
Black and green clayey shale	79	260
Hard shale	1	261
Black shale	38	299
Hard oil sand	41	340
Soft oil sand	61	401
Hard sandstone	2	403
Soft oil sand	6	409
Hard sandstone	2	411
Soft oil sand	2	413
Clayey shale	3	416
Hard sand	4	420
Alternating clayey shale	14	434
Black shale	60	494
Hard sandstone and shale	5	499
Black shale	21	520
Green clayey shale and sandstone	70	590
Hard sandstone	1	591
Clayey shale and sandstone	20	611
Very hard shale or "shell," gas underneath	1	612
Clayey shale and sandstone	6	618
Clayey shale and hard sandstone	21	639
Soft shale and sand; some oil	19	658
Stiff clay and hard sandstone	31	689
Hard sandstone	1	690
Hard sandstone and shale	10	700
Hard sandstone	9	709
Hard sand, mostly shale	21	730
Hard siliceous shale or "shell;" "oil cap"	3	733
Oil sand and clayey shale	7	740
Oil sand, good	15	755
Stiff clayey shale	7	762
Oil sand and shale	4	766
Hard sandstone and shale	2	768
Oil sand	35	803
Clayey shale	30	833
Hard shale or "shell"	2	835
Water sand	33	868
Clayey shale	5	873
Water sand	30	903
Clayey shale	3	906
Sand	29	935

AREA ONE-FOURTH MILE NORTHWEST OF TEMPLE ROAD AND WESTERN AVENUE.

The underground geology in the vicinity of the little group of wells in the SE. ¼ sec. 14, T. 1 S., R. 14 W., one-fourth mile northwest of the corner of Temple road and Western avenue, introduces a new structural factor in the shape of a northeast-southwest line of disturbance. In a journey westward through the western field this is the first evidence encountered of the secondary zone of disturbance which to the southwest develops into the Salt Lake flexure. The line of disturbance or fault appears to extend in a southwesterly direction from the northeast corner of the SE. ¼ sec. 14, through a point 80 feet west of Loma Vista well No. 5, and thence indefinitely toward the Salt Lake field.

East of this line of disturbance the main oil zone, which is here from 80 to 90 feet thick, is encountered at a depth of between 195 and 210 feet, the overlying beds consisting of Pleistocene sand and gravel near the surface, with thin-bedded shale and fine sandstone below. The wells yield as high as 20 barrels per day when they first come in, but this production falls off and at the end of two years is in few cases over 2 barrels. The original high production is caused

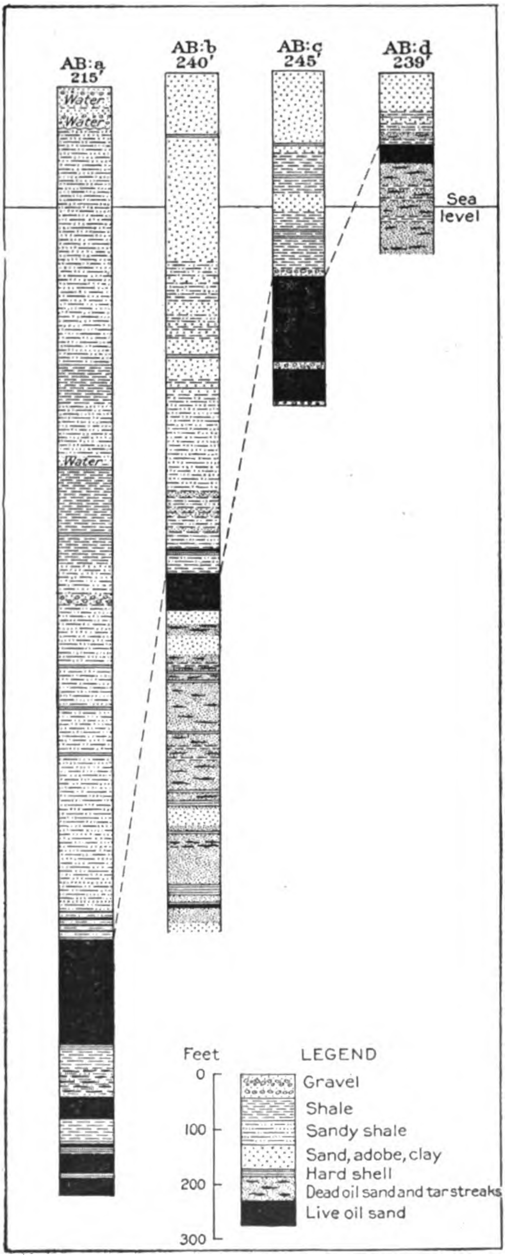


FIG. 16.—Detail of section along the line A-B, Pl. XVIII, western oil field. Small letters indicate locations of wells on section A-B, Pl. XX.

by the gas pressure, which is rather strong in this area. West of the line of disturbance water is encountered in the wells at a depth of 400 feet, but no oil was struck, although one of the wells was continued to 580 feet.

AREA SOUTH OF COLEGROVE.

The wells in and near the SE. ¼ sec. 15, T. 1 S., R. 14 W., about a mile south of Colegrove, penetrate the same strata that underlie the Salt Lake field, a mile and a half to the southwest. The wells reach the oil zone near the surface, where it is unproductive and almost dry, while those of the Salt Lake field encounter it at depths of 1,000 to 3,000 feet, where it is exceedingly rich in oil and gas. The two areas offer an excellent illustration of the differences in saturation of a single zone at different points, and also of the fact that within reasonable depths oil-bearing strata which outcrop at the surface or whose truncated ends are overlain near the surface by comparatively thin deposits of porous material are deprived of most of the petroliferous contents of their upper portions either by slow distillation or by some other process.

The wells of the Colegrove area penetrate Pleistocene sand, usually water bearing at the base for about 50 feet, below which they enter thin-bedded clayey shale, sandstone, and "shell." The northeasternmost wells strike the oil sand at a depth of a little more than 100 feet, and from this point down for at least 300 feet pass through alternating layers of oil sand, clayey shale, and "shell," with here and there one of conglomerate. From the northeastern edge of the Colegrove area the oil sands dip toward the southwest at an angle of about 22°, being encountered at greater and greater depths in the wells as the Salt Lake field is approached. The wells farthest northeast start down in beds which underlie what has been called the "first" of "150-foot" oil sand, but those situated southwest of the middle point of the line dividing the SW. ¼ from the SE. ¼ of sec. 15 penetrate this sand at depths varying from 100 feet down. A well located about one-eighth of a mile west of the middle of the south line of sec. 15 strikes this first oil sand at 722 feet and from this depth down to 1,532 feet penetrates an almost continuous series of oil- and gas-bearing sandstone and sandy shale interbedded with clayey shale and thin layers of hard siliceous shale or "shell." For some reason the sands here are not very productive and no important wells have been developed over this part of the area.

Northeast of the Colegrove area the oil-bearing shale and sandstone pass over the Los Angeles anticline and extend in low folds toward Prospect Park. Traces of oil and gas have been found in these beds in nearly all the wells drilled between the productive belt and the Prospect Park region, but no accumulations of consequence have been encountered.

The three following well logs indicate the character of the strata in the Colegrove area. They are given in order down the dip of the strata from the northeast edge of the area toward the Salt Lake field.

Log of well on northeast edge of the group drilled in the SE. ¼ sec. 15, T. 1 S., R. 14 W., Los Angeles.

[Elevation, 239 feet above sea level.]

	Thickness.	Depth.
	Feet.	*Feet.*
Soil	6	6
Hardpan	8	14
Blue clay	21	35
Gray clay	15	50
Fine black sand and clay; water at 47 feet, but soon exhausted	22	72
Fine black sand and shale	40	112
Oil sand; showing of oil from 60 to 119 feet	7	119
Sandy shale	6	125
Alternating brown shale and oil sand	29	154
Shale	6	160
Tar sand in 3-foot layers	36	196
Tar sand separated by thin layer of shale	84	280
Tar sand; dry toward top; tar bed at base	37	317
Quicksand with water	5	322

Log of well on southwest edge of the group drilled in the SE. ¼ sec. 15, T. 1 S., R. 14 W., Los Angeles.

[Elevation, 245 feet above sea level.]

	Thickness.	Depth.
	Feet.	*Feet.*
Red sand	50	50
Yellow clay	83	133
Hard "shell"	4	137
Sandstone and shale	10	147
Shale; 1-foot "shell" at 186 feet	108	255
Tar sand	1	256
Shale; 1-foot "shell" at 284 feet; 3-foot "shell" at 302 feet	7	363
Conglomerate	1	364
Shale	7	371
Oil sand; 1-foot "shell" at 380 feet; 4-foot "shell" at 448 feet; 1-foot "shell" at 484 feet	156	527
Conglomerate	10	537
Oil sand	9	546
Conglomerate	2	548
Oil sand	48	596
Conglomerate	5	601

Log of well one-eighth mile west of middle of south line of sec. 15, T. 1 S., R. 14 W., Western Oil Field, Los Angeles.

[Elevation, 240 feet above sea level.]

	Thickness.	Depth.
	Feet.	*Feet.*
Sandy clay	11	11
Yellow clay	29	40
Water sand	70	110
Hard shale or "shell"	2	112
Blue clay	81	193
Hard shale and sandstone	11	204
Brown sandy shale; very sticky between 264 and 284 feet	139	343
Clayey shale; 2-foot "shell" at 506 and 570 feet	349	692
Alternating clayey shale and fine sandy shale to sandstone	80	772
Tar oil sand	6	778
Alternating shale and barren sand	12	790
Clayey shale, changing to sandy shale; 6 feet of coarse sand at 815 feet	60	850
Coarse gravel with gas and oil	2	852
Hard silicoous shale or "shell"	6	858
Sandy shale; considerable gas	17	875
Clayey shale	15	890
Oil sand carrying heavy oil	35	925
Alternating "shell" and sand with considerable gas and oil	35	960
Very hard "rock"	20	980
White sand with streaks of tar	20	1,000
Tar sand	6	1,006
Very hard "rock"	5	1,011
Sand rock	30	1,041
Tar sand in 3 to 10 foot strata, alternating, with "shell"	59	1,100
Tar sand with thin streaks of shale; more gas	85	1,185
"Shell"	5	1,190
Alternating tar sand and shale, showing of oil and gas between 1,249 and 1,254 feet	64	1,254
Tar sand with occasional hard "shell" layers	36	1,290
Alternating sand and shale, showing of oil and gas	6	1,296
Hard coarse sandstone	7	1,303
Sand interstratified with brown sandy shale	5	1,308
Hard "shell"	10	1,318
"Shell" and gray sand, carrying tar and gas; sand looks like water sand, but no water in it	18	1,336
Water sand	12	1,348
Hard "rock"	2	1,350
Sand, carrying tar and water	10	1,360
Fine sand carrying considerable tar	4	1,364
Dry tar sands interbedded with "shell;" "shell" from 1,364 to 1,366 feet	9	1,373
White sand, hard at base	13	1,386
Tar bed, with pure tar	7	1,393
White quicksand with water	3	1,396
Tar sand alternating with thin "shell;" hard "shell" 1,467 to 1,478 feet	82	1,478
White sand	15	1,493
Hard shell with gas and heavy oil just below it	3	1,496
White sand containing tar and gas	12	1,508
Sand and brown shale	7	1,515
Hard shell	5	1,520
White sand	8	1,528
Very hard shell with some tar and gas beneath it	4	1,532
Hard sand with streaks of shale	12	1,544

STRUCTURE.

The structural conditions in the western field are graphically illustrated by Pl. XX, which shows a section along the line C-D from 1 mile southwest of the corner of Western avenue and Temple road to Edgemont (see also fig. 15), and another section along the line A-B, showing the underground geology from the Colegrove area to the Salt Lake field (see also fig. 16), and by fig. 14, a section along Hoover street. The principal structural feature in the field is the northwestward continuation of the Los Angeles anticline. The trend of this flexure changes from N. 80° W. to N. 65°–70° W., at the east end of this field, west of Coronado street. The area of the change of trend lies northeast and southwest from the corner of Sixth and

Hoover streets, and is one of considerable fracturing and distortion, as is evidenced by the dips which occur in its vicinity. Northwest of the disturbed area the strata along the southwestern limb of the anticline are inclined at angles of 20°–25°, S. 20°–25° W. As the beds approach the axis they flatten out, passing gently over it into the low local folds and flexures which characterize the rolling country to the north, not only of the western, but of the central field also. (See fig. 14.)

The Los Angeles anticline is complicated by faulting in this field, as it is in the region to the east. This is well shown by an exposure on First street, one block east of Vermont avenue, where the beds are much distorted and broken up. From this point the line of disturbance passes near the junction of Rosedale avenue and the old Hollywood and Cahuenga Valley Railroad; thence, as shown by well records, across Western avenue at a point somewhere less than a quarter of a mile north of Temple road, and thence into the group of wells which lie about a quarter of a mile northwest of the corner of Western avenue and Temple road. A new line of disturbance, probably a fault and doubtless related to the Salt Lake flexure (see p. 194), is encountered in this last-mentioned group of wells and extends in a northeast-southwest direction across the trend of the anticline. The geologic conditions are different on the two sides of the fault line, and from this it is safe to assume that the structural conditions are also different, but just what effect the fault has had on the main anticline is problematical. Evidence offered by the logs of the Colegrove group of wells and of other wells between this group and the Salt Lake field and by the great monocline in the region of Cahuenga Pass, in the Santa Monica Mountains to the north, appears to indicate a northwestward extension of the anticline past the transverse fault, toward the mouth of Laurel Canyon. A glance at the geologic map of the western field clearly demonstrates that most of its structural features are determinable only by a comparison of the well logs. It has therefore been necessary to depend almost entirely on these logs in working out the structure of the great southwestern limb of the Los Angeles anticline. In the area southwest of the Baptist College, where the anticline recovers from the distortion and fracturing accompanying its change of strike farther east, this southwestern limb (or monocline, as it may be considered in this territory) dips at angles of 20°–22°, S. 20°–30° W. The dip near Western avenue and Temple road is a little more toward the south, and, being nearer the axis, is but about 12°, while half a mile to the southwest the dip is approximately 26°. One-half mile farther west the slope flattens out to 23°, and still farther northwest, in the area southwest of the Colegrove group of wells, it is only 22°, continuing practically at this angle, at least so far as its southwestern element is concerned, to the Salt Lake field. Evidence secured in this field indicates that a local flexure trending northeast and southwest probably changes the general dip of the beds from southwest in the region of the Colegrove group of wells to west and then to northwest toward the center of the Salt Lake field.

The contour lines on the map (Pl. XIX) give an approximation of the depth of the top of the upper oil sand or zone below Los Angeles city datum (255 feet above sea level).

SALT LAKE FIELD.

LOCATION.

The Salt Lake field—so named from its first important producing company—occupies an area approximately a mile square near the intersection of Fourth street and La Brea road, 7 miles west of the business portion of Los Angeles. The productive territory as now developed embraces the northwestern part of the SE. ¼, the northeastern part of the SW. ¼, and the southern part of the N. ½ sec. 21, T. 1 S., R. 14 W. In addition to this there are some important wells in the central part of the E. ½ sec. 20 and some small producers in the NW. ¼ sec. 28.

The field occupies a part of the Los Angeles-Santa Monica plain, which extends southward with a gradually lessening slope from the base of the Santa Monica Mountains toward the hills southwest of Los Angeles. (See Pl. XXIII.)

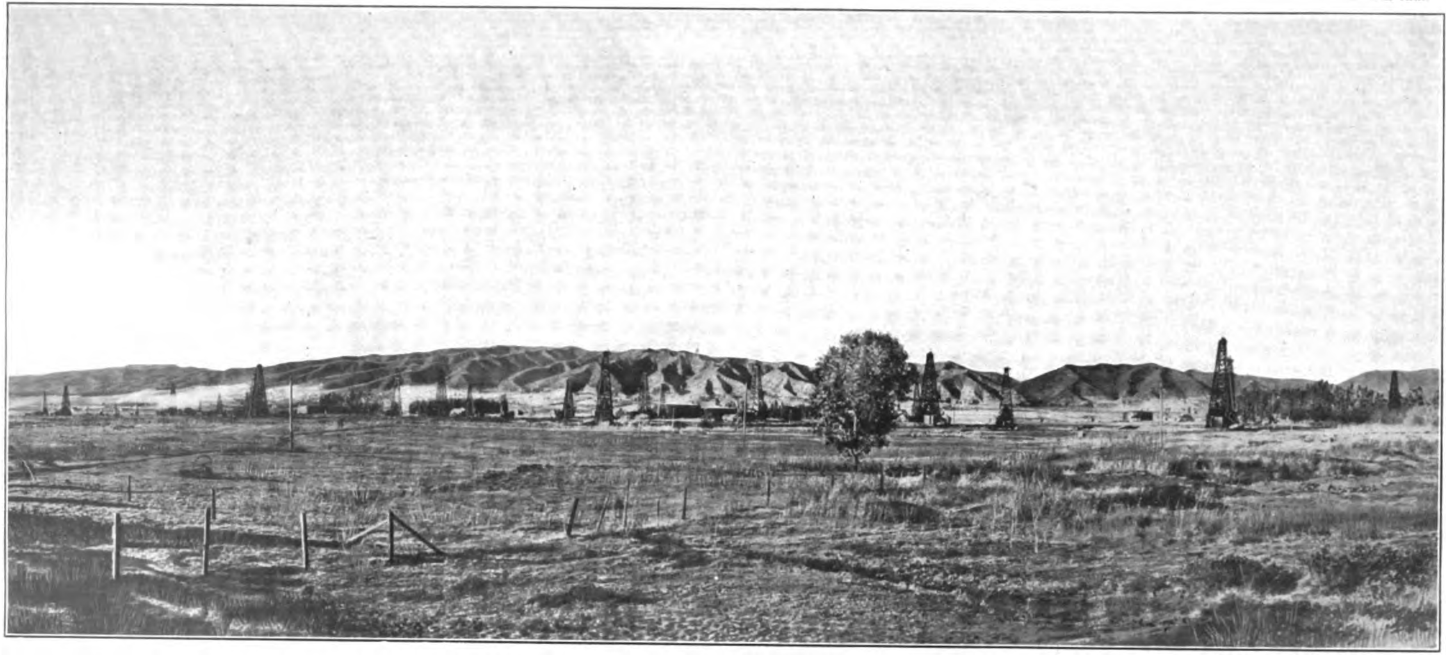
GEOLOGY.

GENERAL STATEMENT.

Alluvium and Pleistocene deposits of gravel, sand, and clay cover the plain in the region of the Salt Lake field, but surface outcrops of other beds are to be found no nearer than about 2 miles from the present developed territory. The well logs and a study of the adjacent territory indicate, however, that the formations involved in the geology of this field include at least a part of those exposed to the east in the vicinity of the Los Angeles city field. They are (*a*) 2,000+ feet of Puente sandstone; (*b*) 2,000± feet of upper Puente shale and thin-bedded sandstone; (*c*) 2,000+ feet of Fernando clayey and sandy shale, sandstone, and gravel, and (*d*) an unconformable capping of Pleistocene gravel, sand, and clay varying in thickness from 40 to 190 feet or more, the whole covered by alluvium. A detailed description of these formations is given in the discussion of the general geology of the district and will not be repeated here.

OIL SANDS.

The most productive sands occur at the top of the Puente formation although traces and locally more or less important accumulations of oil and gas are found in the shale above the principal oil zone.



SALT LAKE FIELD, LOS ANGELES.

Looking north from near lagoon.

The oil is supposed to be derived largely from the diatoms and other minute organic remains found in the underlying shale and finds its way into the sandy layers mainly through the multitude of joint cracks which penetrate both the shale and sandstone.

BREA DEPOSITS.

The brea deposits in the Salt Lake field are the most important in the Los Angeles district. They cover a considerable territory in sec. 21. (See Pl. XXIV, *B*.) A number of years ago large quantities of this brea were removed and used for paving purposes, the resultant depression filling up with water and forming a lagoon. The brea is largely the result of the impregnation of porous sand and soil by oil oozing up from below. That the process is still going on is evidenced by the heavy oil which may be seen oozing from the banks of the lagoon and of several other brea pits in the vicinity. Large quantities of gas are also escaping in the same region, as is shown by the intermittent streams of bubbles which rise to the surface of the water in the lagoon and other depressions thereabouts. (See Pl. XXIV, *B*.) The logs of several wells indicate that brea occurs in the basal Pleistocene beds over a considerable territory contiguous to the lagoon where it is invisible on the surface. The formation of brea over an area relatively so large implies the escape of vast quantities of oil from the underlying Tertiary beds. This escape of the oil and gas is probably made possible by the fractured condition of the rocks. On the evidence offered by the great brea deposits and the large quantities of escaping oil and gas in the region of the lagoon the theory is advanced that considerable fracturing has accompanied the formation of the Salt Lake flexure.

GEOLOGY OF THE WELLS.

For the convenience of discussion of the underground geology, the Salt Lake field will be divided into two parts by a hypothetical line running in a general northeast-southwest direction through the lagoon and coinciding in a general way with the axis of the supposed Salt Lake flexure. The area to the northwest of this line contains most of the productive wells, and there are no important producing wells in the area southeast of the line.

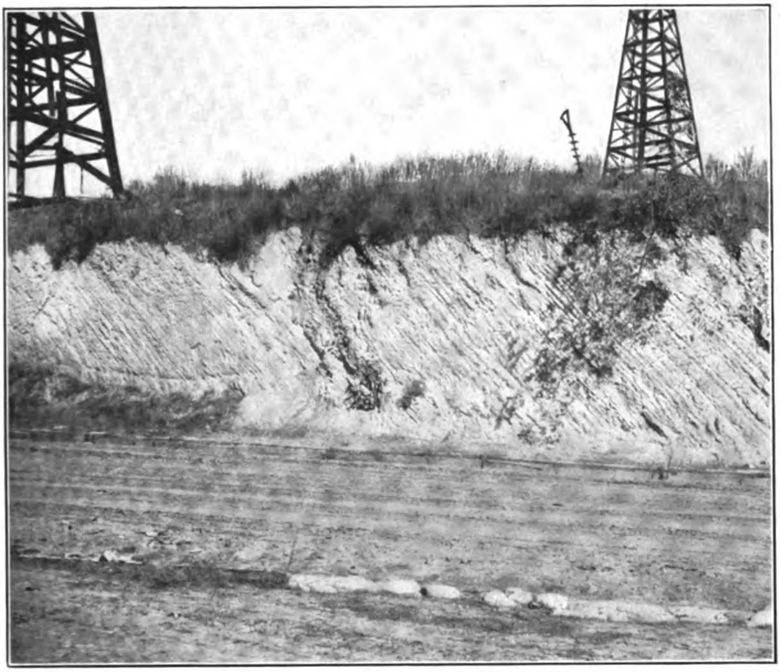
AREA NORTH AND NORTHWEST OF THE LAGOON.

In the area north and northwest of the lagoon the wells for the first 50 to 100 feet penetrate alluvium and Pleistocene clay, coarse sand, and gravel—the mantle of the older formations. The Pleistocene beds usually carry two water-bearing layers, one at a depth of 20 to 30 feet, the other (which appears to lie at the base of the formation) at 50 to 100 feet from the surface. In some of the wells the lower layer is highly charged with sulphur and other minerals, which are probably derived from the underlying shale. These surface waters are usually shut off in the sandy or clayey shale at depths of about 150 feet. Brea and heavy oil are also occasionally encountered at the base of the Pleistocene, having accumulated at the top of local fracture zones which penetrate the underlying oil-bearing strata. In fact in some parts of the field, especially in the vicinity of the supposed flexure, oil appears to impregnate the soil and rocks "from the grass roots down."

From the base of the Pleistocene to the first important oil sand, which is struck at 1,000 to 3,000 feet, the rocks penetrated are essentially clayey and sandy shale (the latter known locally as "adobe") interbedded toward the base with a few 1- to 5-foot layers of hard siliceous or calcareous shale (the "shell" of the drillers). The great bulk of this shale probably belongs to the Fernando formation. The sandy and clayey facies of the shale appear to grade into each other both laterally and vertically, so that the personal equation of the driller enters largely into their differentiation. Gravel and coarse-sand lenses are also encountered in some of the wells, but these are usually only local in extent and of little importance.

Gas and oil, increasing in quantity downward, are found in many of the beds of the formation, the most important accumulations occurring as a rule just beneath the hard, impervious "shell" layers. Some of these gas accumulations or pockets are confined under great pressure and when penetrated by the drill have been known to clean out the well with considerable force. The shale beds near the flexure or anticline appear to be more petroliferous than the same layers farther away, to the northwest of the flexure. This is doubtless due to the more or less fractured condition of the rocks in the vicinity of the disturbance, which allows the oil and gas to penetrate many of the beds of the shale which otherwise would be impervious. A persistent stratum of salt water occurs beneath a "shell" layer at about 950 to 1,000 feet above the top of the first important oil sand in the area northwest of the flexure, but does not appear in any of the wells southeast of it. (See fig. 17.) Salt water is also encountered in some of the wells at horizons 150 to 200 feet and 650 feet above the oil zone.

The oil zone proper varies in thickness from 150 to 500 feet and consists of fine to coarse sand interstratified with clayey shale and "shell." The logs of a few wells near the flexure show no well-defined oil sand, but rather a series of thin productive sands interbedded with clayey and sandy shales. Whether the sand occurs as persistent layers or as lenses is problematical, although from the evidence in hand it appears highly probable that it is present in both forms within the area under discussion. It is known, however, that the uppermost important oil sand in the wells over a large part of the



A. CHARACTERISTIC THIN-BEDDED PLIOCENE SANDSTONE, LOS ANGELES OIL FIELDS.

B. **LAGOON IN SALT LAKE FIELD, LOS ANGELES.**

Showing floating oil and bubbling water due to escaping gas.

area northwest of the flexure appears to occupy the same horizon. The sands beneath the uppermost persistent layer vary somewhat in

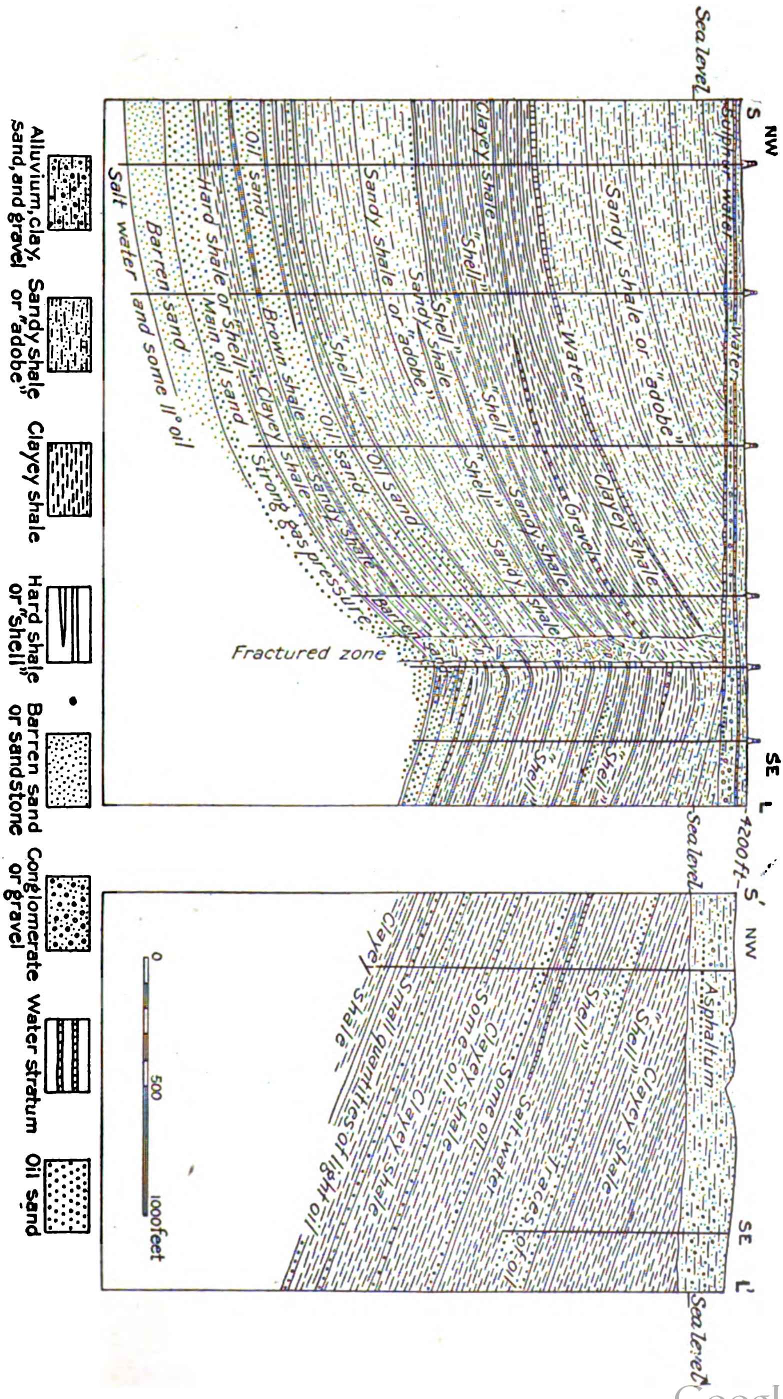


FIG. 17.—Northwest-southeast sections along the lines S–L and S'–L', Pls. XVIII, XIX, Salt Lake field, showing the character of the Salt Lake flexure and the mode of occurrence of the oil-producing strata.

thickness and composition in the different wells. This is to be expected, since individual layers in surface outcrops of similar beds in the Los Angeles region undergo important changes of thickness and grain within remarkably short distances. The upper oil sand on the northwest side of the flexure appears to become less and less impregnated with petroleum as it approaches the apex of the flexure. This condition is probably due to structural causes, such as the loss of the oil through fractures, although it may possibly be accounted for by a slight change in the grain of the sand near the flexure. The same beds, however, continue to carry considerable quantities of gas as they pass over the line of the disturbance.

The "main sand," which yields the bulk of the oil, is apparently fairly constant over a large part of the field. This sand is approximately 100 to 125 feet thick, rather coarse-grained, and highly impregnated not only with oil but with gas also. The tapping of the main sand usually results in the production of a "gusher," owing to the great pressure under which the gas is confined. The retention of the oil and gas in this sand is due to the presence of an overlying bed of impervious "shell," capped by 50 feet or more of hard clayey shale. The gravity of the oil in the same stratum is said to be different at different points down the dip. An illustration of this is found in a series of four wells running across the strike of the oil sand in the northern part of the field. The well highest up on the dip yields 14° oil; the next lower down, about 150 feet from the first, 15°; the third, 150 feet from the second, 16°; and the fourth, or lowest of the series, 100 feet from the third, 17°.

The two following well sections, one near the flexure, the other farther away and down the dip from it, are typical of the Salt Lake field:

Typical well log near the flexure, on its northwestern flank, Salt Lake field.

[Elevation about 225 feet; dip of strata approximately 40°.]

	Thickness.	Depth.
	Feet.	*Feet.*
Clay	36	36
Sand and gravel	24	60
Heaving sand; first water cased off at 110 feet	30	90
Clayey shale	70	160
"Adobe" (sandy shale)	90	250
"Adobe," with salt water at base	12	262
Clayey shale; 2-foot "shell" at 275 feet	13	275
Clayey shale; no water	85	360
Clayey shale; 4-foot "shell" at 398 feet	38	398
Clayey shale	47	445
"Adobe" and clayey shale	41	486
Sticky "adobe"	19	505
Coarse gravel and "adobe"	21	526
"Adobe;" 4-foot "shell" at 632 feet	106	632
"Adobe;" last 10 feet very sticky	40	672
Clayey shale, 4-foot shell at 701 feet	29	701
"Adobe;" "shell" at 785 feet	94	795
Sticky "adobe;" second water shut off temporarily	5	800
"Adobe;" considerable water	118	918

Typical well log near the flexure, on its northwestern flank, Salt Lake field—Continued.

	Thickness.	Depth.
	Feet.	*Feet.*
"Adobe;" layer of soft clayey shale at 960 feet	42	960
"Adobe"	22	982
"Adobe" and small streaks of white sand; some water	40	1,022
"Adobe;" some clayey shale and sand; "shell" at 1,040 feet	29	1,051
Fair showing of oil in "adobe;" small "shell" at 1,075 feet	25	1,076
Sandy shale; good showing of oil between 1,070 and 1,080 feet	24	1,100
Shale; much gas; oil still coming in	10	1,110
Sand and shale; lots of oil	22	1,132
Shale carrying much oil	40	1,172
Shale and oil sand mixed; much gas and oil	44	1,216
Same formation; gas and oil	9	1,225
Broken shale formation; considerable oil	5	1,230
Shale and oil sand; considerable oil	20	1,250
Shale; gas increasing; oil	18	1,268
Shale and "adobe;" lots of oil	28	1,296
Shale; considerable oil	12	1,308
Passed through pulverized slate from 1,310 to 1,315 feet, light oil showing under this	11	1,319
Shale; oil still coming in	19	1,338
Gray shale; gas strong	4	1,342
Shale containing oil; pocket of gas at 1,340 feet	5	1,347
Shale	39	1,386
"Adobe;" considerable gas	19	1,405
"Adobe;" oil coming up on bit; gas flow heavy; well filled for 400 feet with mud, water, and oil	5	1,410
Big flow of gas; filled pipe 140 feet; good showing of oil	34	1,444
Light-colored shale; no mud and no oil	54	1,498
Light oil; large amount of gas; well filling rapidly with oil within 100 feet of top; large "shell" at 1,495 feet, under this the heavy flow of gas and oil; another shell at 1,505 feet	12	1,510
Well full of oil, commenced flowing; continues in oil sand	14	1,524
Struck shell; bottom of well; gushed to top of derrick; big flow at 1,495 feet	17	1,541

Oil zone, 490+ feet (1,051 to 1,541+); thickness of producing sands, 347+ feet.

Typical well log 1,500 feet northwest of the flexure, Salt Lake field.

[Elevation about 200 feet.]

	Thickness.	Depth.
	Feet.	*Feet.*
Alluvium, clay, and sand; water at 28 feet, sulphur water at 49 feet	50	50
"Adobe" or sandy shale	750	800
Hard "shell;" salt water under "shell"	3	803
Clayey shale; 1 to 6 foot "shell" layers every 25 to 50 feet	297	1,100
Hard "shell;" salt water under "shell"	2	1,102
"Adobe"	163	1,265
Tar sand	5	1,270
"Adobe" with occasional clayey shale layers	470	1,740
Oil sand	20	1,760
Clayey shale	30	1,790
Oil sand	10	1,800
Clayey shale	20	1,820
Oil sand	20	1,840
Clayey shale	2	1,842
Oil sand	123	1,965
Tough brown clay	10	1,975
Oil sand	25	2,000
Clayey shale	10	2,010
Oil sand	10	2,020
Clayey shale	86	2,106
Oil sand (main sand)	129	2,235
Barren white sand	150	2,385
Sand with warm salt water and some 11° oil	10+	2,395+

Oil zone, 495 feet (1,740 to 2,235); thickness of producing sands, 337 feet.

AREA SOUTH AND SOUTHEAST OF THE LAGOON.

The underground geology in the area south and southeast of the lagoon is similar only in a very general way to that of the area to the north. The dip of the strata is probably toward the south or southeast, although there are some indications of steep northerly dips immediately southeast of the lagoon. The superficial or Pleistocene deposits become thicker and coarser toward the southeast, those in the SE. ¼ sec. 28 attaining a thickness of 190 feet and consisting of clay in the upper 20 feet and sand and gravel in the lower portion. Deposits of asphaltum appear to be common at the base of the Pleistocene, and in at least one of the wells heavy oil was encountered not far below the middle of the formation. (See fig. 17.) Water is usually found in these superficial beds, as in the area north of the lagoon.

From the base of the Pleistocene down to the bottom of the deepest wells the rocks appear to be largely clayey shale, interbedded at varying intervals with hard "shell" layers. Some sandy beds and a few pebbly lenses are also encountered in drilling. Indications of oil are abundant throughout certain horizons of the shale, but no really important productive sands have yet been found in the area. The wells near the lagoon on the south strike moderately productive sands between 700 and 1,000 feet, while those somewhat farther away get good showings of oil at less depths. In the territory a mile or so southeast of the lagoon the shale contains here and there thin oil-bearing strata beneath the "shell" beds from 400 feet down, but nothing approaching a pay sand has been reached here. Salt water is reported as very troublesome below a depth of about 500 feet in this last locality. It is also found in most of the other wells of the southern area. The wells near the lagoon usually yield flowing water.

The three following logs are characteristic of their respective localities.

Log of well near the middle of the north line of sec. 28, T. 1 S., R. 14 W. (immediately southeast of the lagoon), Salt Lake field.

[Elevation, 175 feet.]

	Thickness.	Depth.
	Feet.	*Feet.*
Alluvium and clay	40	40
"Dead" oil sand and water	40	80
Clayey shale; occasional layers of hard "shell" averaging 2 feet in thickness and in places contining small quantities of oil and gas beneath them	620	700
Good oil sand flowing 1 barrel per day	5	705
Clayey shale similar to that from 80 to 700 feet	765	1,470
Clayey shale, but no oil sand or signs of oil in it	730	2,200

Log of well in the eastern part of the SE. ¼ sec. 28, T. 1 S., R. 14 W. (1 mile southeast of the lagoon), Salt Lake field.

[Elevation, 180 feet; dip approximately 20°.]

	Thickness.	Depth.
	Feet.	*Feet.*
"Adobe"	28	28
Sand and a little heavy oil (asphaltum)	100	128
Quicksand	45	173
Blue clayey shale	127	300
Hard "shell"; blue limestone	4	304
Blue clayey shale	226	530
Hard "shell"; blue limestone	4	534
Blue clayey shale	166	700
Hard "shell"; blue limestone	6	706
Blue clayey shale	229	935
"River" sand; some oil	5	940
Clayey shale	300	1,240
"River" sand having excellent quality but small quantity of light oil	5	1,245
Clayey shale	55	1,300
Hard shell; blue limestone	15	1,315
Clayey shale	81	1,396

Log of well in the western part of the NW. ¼ sec. 28, T. 1 S., R. 14 W. (1 mile south-southwest of the lagoon), Salt Lake field.

	Thickness.	Depth.
	Feet.	*Feet.*
Sandy clay	90	90
Water sand containing heavy oil (asphaltum)	90	180
Heaving sand (gas); little water; no oil; carries considerable quantities of pebbles	325	505
Blue clayey shale interbedded with beds of sand and pebbles 1 foot or so in thickness carrying oil; richest horizon at about 700 feet	358	863

STRUCTURE.

Owing to the almost complete absence of surface evidence in the immediate vicinity, the determination of the local structure in the Salt Lake field depends largely on the interpretation of the well logs. Unfortunately, not all of these were available at the time of the writer's visit to the field, so that the conclusions reached, although probably correct in the main, lack that detail and definiteness which is so desirable in an economic report of this sort.

The strictly local structure of the field under discussion will be more fully comprehended if its relation to the general structure of the Los Angeles district as a whole is again briefly outlined. Practically all the productive oil sands of the different Los Angeles fields lie on the southern limb of a flexure, usually a more or less well-defined anticline, whose axis extends in a westerly direction to the region approximately half a mile north of Westlake Park, where it bends about 20° to the north and extends to a point about three-fourths of a mile southeast of Colegrove and something over a mile northeast of the Salt Lake field. Here it appears to bend again to the north, probably trending about N. 60° W. In the Los Angeles city fields, that is, between the Catholic Cemetery and the Westlake Park region, the southern limb of the flexure dips normally at angles varying from 30° to 80°, while to the west, along that portion having a northwesterly trend, the dips flatten to 20° or 25°. The Salt Lake oil field is located on the northwestern flank of a minor, but probably somewhat complex fold or fault, or both, developed on the comparatively low-dipping southwestern limb of the major flexure just described. The dip of this flank of the local fold is reflected in a general way by the surface slope, which descends gently from the region of the present productive field northwestward toward Sherman. This slope probably indicates a Pleistocene or post-Pleistocene orogenic movement similar to but apparently of much less magnitude than that which produced the original flexure.

The exact nature of the local flexure is not known, but it is probably an anticline, more or less complicated by faults near the apex. Its axis extends in a general northeast-southwest direction. The logs of certain wells located southeast of the lagoon appear to indicate the presence of a minor anticline developed just south of the main flexure and separated from it by a fault. Still other evidence suggests a local dome-shaped structure, or quaquaversal, having its summit in the region of the lagoon. The length of the Salt Lake flexure is unknown, although the available data seem to indicate its extension at least from a point near the center of the SE. ¼ sec 15, T. 1 S., R. 14 W., as far as the lagoon in the SW. ¼ sec. 21. Whether or not it continues farther to the southwest is problematical.

The large accumulations of brea in the immediate vicinity of the lagoon and to the north and northwest of it, in addition to the constantly exuding oil and escaping gas over the same area, indicate some sort of a profound local disturbance or fracture in the underlying beds. If this disturbance has an extensive longitudinal dimension in a northwesterly direction from the lagoon, as some of the evidence suggests, then it may possibly cut off the Salt Lake flexure from a southwesterly extension beyond the lagoon. If, however, the structure in the vicinity of the lagoon is a local bulge or dome in the underlying beds it is quite likely that the Salt Lake flexure may have a considerable southwestern prolongation.

The contour lines on the map of the Los Angeles field (Pl. XIX) and the section shown in Pl. XX, A–B, and in fig. 17 illustrate the writer's ideas concerning the local folds. From the map it will be seen that the strike of the oil sand probably swings around from a nearly east-west line in the region north of the lagoon to a direction slightly west of north in the NE. ¼ sec. 21. The dip of the sand in the region about the center of sec. 21 does not appear to be much more than 10° or 15°, but it increases rapidly in steepness toward the southeast up the rise and probably also toward the northwest, or down the dip.

The region immediately southeast of the Salt Lake flexure, although supporting some small producing wells—one of which attains a depth of nearly 3,000 feet—does not compare in productiveness with the territory to the northwest. This condition may be explained on several hypotheses, the two most probable being either (*a*) that the Salt Lake flexure is accompanied by a fault which has dropped the productive sands on the southeast down out of reach of the drill, or raised them up to such an elevation that they were eroded away in a period subsequent to the faulting, or (*b*) that the continuation of the productive beds passes over the flexure (in this case an anticline) and down on the southeastern flank, but under conditions unsuited to the accumulation of oil in large quantities. The second hypothesis is represented diagrammatically by fig. 17.

Faulting may be responsible for the cutting off of the upper oil sands immediately to the northwest of the axis of the flexure. If this be true it seems likely that the oil sand at the apex, which in fig. 17 is correlated with the main oil sand of the productive field, should be correlated with the uppermost sands northwest of the fold. In this case the fault would have a downthrow of about 250 feet on the southeast.

DEVELOPMENT.

There are at present (February, 1906) between 75 and 80 productive or drilling wells in the Salt Lake field, belonging to the following companies: Salt Lake Oil Company, about 50 or 55; Arcturus Oil Company, 9; Utah Oil Company, 1 (these three companies controlled by the Associated Oil Company); A. F. Gilmore, 4; Pacific Light and Power Company, 4; E. P. Clark Oil Company, 7. In addition to the wells mentioned above, there are several comparatively small producers, belonging to the last-named company. These are located near the northern half of the line separating secs. 28 and 29, and are pumped intermittently. The wells north of the Salt Lake flexure vary from 1,200 feet to over 3,100 feet in depth, the deeper wells being as a rule the more productive and yielding the lighter oil. The individual wells produce from 20 to over 1,000 barrels a day, the average being about 100 barrels. Owing to the tremendous gas pressure nearly all the wells "gush" when they first come in, and it is said that one of the deep wells produced about 18,000 barrels a day for a short time after its inception. The gravity of the oil varies from 11° to 22°, the heaviest oil coming, it is said, from an isolated sand below the main productive zone. The average for the field is between 16° and 18°.

The large quantity of gas which comes from the wells is used mainly for the generation of power for operating and development, although a small amount is used in the field for domestic purposes.

CONCLUSIONS CONCERNING FUTURE DEVELOPMENT.

Anyone at all familiar with the conditions of occurrence of petroleum in the California fields knows that any but the most tentative predictions as to the location of the oil are extremely hazardous. The following conclusions, based on the evidence in hand, although lacking definiteness for obvious reasons, may be of some assistance to those carrying on development in the Los Angeles fields.

CITY FIELDS.

All of the evidence, both geologic and that obtained by exploitation, indicates that the productive territory in the region of the eastern, central, and western fields has been largely developed, in fact overdeveloped, for the most part. It is very improbable, therefore, that prospecting outside of the already proved productive area, either immediately north or south of the oil belt, would result in success.

EAST OF LOS ANGELES RIVER.

Certain outcropping oil sands in the ravine occupied by the old Rapid Transit Railroad track indicate that oil-bearing strata underlie the region east of Los Angeles River and south of this ravine. A number of wells have been sunk in this territory, however, and the greatest recorded production has been that of the Scott & Loftus well No. 1, which is said to have yielded 7 barrels of 17° B. oil per day.[a] It is to be borne in mind that the deepest well so far sunk in this territory is less than 1,000 feet deep and that deeper wells farther down the dip than those already drilled may possibly yield better results, providing water does not interfere with their operation.

The structure of the Fernando sand and gravel in the area northeast of Brooklyn Heights appears to be analogous to that in certain productive areas in the eastern field, as well as in the Puente Hills and Sulphur Mountain (Ventura County) fields. Moreover, the area mentioned is in the same formation and lies in the strike directly between the eastern field and the Whittier field. It does not seem improbable, therefore, that oil-bearing strata underlie the area here considered, although no direct evidence, such as seepages and brea, are known in the vicinity.

Were the thick deposits of Pleistocene and late Fernando sediments that conceal the structure of the older beds in the Raphetto Hills removed, these hills might be found to offer a remunerative field for exploitation with the drill.

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[a] Watts, W. L., Bull. California State Mining Bureau, No. 19, 1900, p. 73.

SOUTHWEST AND WEST OF LOS ANGELES.

It seems probable that the productive zone of the Salt Lake field extends northward and possibly a little westward from the territory now developed. Just where the northern limit is located is problematical, but it is quite certain that it is considerably south of the base of the Santa Monica Mountains. Within this northern extension the beds in general dip to the west, and for this reason the most productive area will doubtless be found west of La Brea road. East of this road the oil sands approach the surface and consequently yield smaller quantities and heavier oil than the same beds farther down the dip.

The region southeast of the Salt Lake flexure, as shown by several wells, does not appear to offer many inducements for exploitation, at least in the immediate vicinity of the Salt Lake field. Farther east, however, in the region west and southwest of Westlake Park, should deep wells strike a local flexure similar to that in the Salt Lake field they would doubtless yield large quantities of oil and gas. If the disturbance or fracture already mentioned as occurring in the vicinity of the lagoon does not have a northwestern extension, terminating the Salt Lake flexure and the productive zone on its northwestern flank, then it appears highly probable that deep wells will strike productive sand in the southern part of section 20 and the northern part of sections 29 and 30, T. 1 S., R. 14 W.

Outside of the territory mentioned in the preceding paragraphs there is little or no evidence of remunerative oil deposits in the immediate vicinity of Los Angeles. Were it not for the great thickness of Pleistocene sand and gravel, which cover the great Los Angeles Plain from the Santa Monica Mountains and Raphetto Hills to the ocean, it would be more than likely that productive territory could be developed over this plain. At least it is almost certain that the oil-bearing strata underlie it, but whether or not the structural conditions are at any place conducive to the accumulation of gas or oil in paying quantities can be determined only by costly exploitation with the drill.

PRODUCTION.

Owing to the large number of independent companies operating in the Los Angeles district, it has been impossible to obtain even approximately complete data concerning the annual production. However, the following figures derived from various sources are probably as nearly correct as any that are available:

Approximate production of petroleum in Los Angeles district, 1895 to 1905, inclusive.

Date.	Field.	Production.
		Barrels.
1895 [a]	Central	729,695
1896 [b]	do	900,000
1897 [c]	Largely from central	1,072,000
1898 [c]	About 50 per cent central, 50 per cent eastern	1,168,000
1899 [c]	43 per cent central, 30 per cent eastern, 27 per cent western	1,032,036
1900 [b]	Central, eastern, and western	1,500,000
1901 [b]	do	2,500,000
1902 [d]	Central, eastern, western, and Salt Lake	3,074,000
1903 [d]	do	2,468,000
1904 [e]	do	1,199,850
1905 [e]	do	2,672,349
		18,315,930

[a] Watts, W. L., Bull. California State Mining Bureau No. 19, 1897, p. 21.
[b] Estimated by the writer.
[c] Watts, W. L., Bull. California State Mining Bureau No. 19, 1900, p. 53.
[d] Estimate of central, eastern, and western fields by Charles A. Blackmar, city oil inspector; Salt Lake field estimated by the writer.
[e] Statistics compiled by division of mining and mineral resources, U. S. Geological Survey.

STORAGE.

The storage facilities of the eastern, central, and western fields are largely confined to wooden tanks in the producing territory. Many of these are small, so that as a rule the operators are unable to hold their product for any considerable length of time. The storage capacity of the refineries in the city is also small, few of the individual refineries having a capacity of over 25,000 barrels.

The storage capacity of the Salt Lake field, on the contrary, is about 390,000 barrels. Steel tanks, holding 20,000 to 55,000 barrels, are largely used in this field, although smaller wooden tanks are employed in a few instances.

TRANSPORTATION.

The oil from the city fields is in large part used locally, being delivered in tank wagons. No pipe lines of any great length exist in the city. The largest is the Union Oil Company's line, from First street and Lake Shore avenue, in the central field, to the Southern Pacific Railroad at Palmetto and San Mateo streets, a distance of about 4 miles.[a] An 8-inch pipe line connects the Salt Lake field directly with Los Angeles, and smaller lines run from some of the properties to tanks and racks on the line of the Los Angeles Pacific Electric Railroad immediately south of the fields.

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[a] Watts, W. L., Bull. California State Mining Bureau No. 11, 1900, p. 169.

BIBLIOGRAPHY OF SOUTHERN CALIFORNIA OILS.

The following is a bibliography of the principal articles referring to the oil industry of California and the geology of the southern California oil districts:

Anderson, F. M. Oil-yielding formations of Humboldt County; Bull. California State Mining Bureau No. 19, Sacramento, 1900, pp. 161–166.

Anonymous. Description of the recently discovered petroleum region in California. Tract. New York, 1865.

Anonymous. Gas making with crude oil in California: Jour. Gas Light, April 28, 1903.

Antisell, Thomas. Geology of the Sierra Susanna and Monica: Pacific R. R. Rept., vol. 7, pt. 2, Washington, 1857, pp. 75–78. Plains of San Fernando, Los Angeles, and San Bernardino: Idem, pp. 79–86. Bituminous effusions: Idem., pp. 107–114, Pl. V, figs. 2, 3.

Arnold, Delos and Ralph. The marine Pliocene and Pleistocene stratigraphy of the coast of southern California: Jour. Geol., vol. 10, Chicago, 1902, pp. 117–138, Pl. IV, figs. 1–7.

Arnold, Ralph. The paleontology and stratigraphy of the marine Pliocene and Pleistocene of San Pedro, Cal.: Mem. California Acad. Sci., vol. 3, San Francisco, June 27, 1903, 420 pp., 37 pls.

———. The Salt Lake oil field near Los Angeles, Cal. In Contributions to Economic Geology for 1905: Bull. U. S. Geol. Survey, No. 285, Washington, 1906, pp. 357–361, fig. 12.

Arnold, Ralph, and Strong, A. M. Some crystalline rocks of the San Gabriel Mountains, California: Bull. Geol. Soc. America, vol. 16, Rochester, N. Y., April, 1905, pp. 183–204, 2 maps.

Blackmar, Charles A. Register of oil wells, with map, Los Angeles city. Register California State Mining Bureau, Sacramento, 1904.

Blake, William P. Geology and natural resources of the region from Mojave River, by Williamsons Pass, to San Fernando and Los Angeles; Los Angeles to San Bernardino and Cajon Pass: Pacific R. R. Rept., vol. 5, pt. 2, Washington, 1856, pp. 65–88, 6 figs., Pl. VI.

Bowers, Stephen. Geology of Ventura County: Eighth Ann. Rept. California State Mining Bureau, for 1888, Sacramento, 1889, pp. 679–690.

Cooper, A. S. The genesis of petroleum and asphalt in California: Sci. Am. Suppl., Sept. 2, Dec. 30, 1893; California Mines and Minerals, San Francisco, 1899, pp. 114–174, 18 figs.; Bull. California State Mining Bureau, No. 16, Sacramento, 1899, 89 pp., 29 figs.

Cooper, H. N. Chemical analyses of California petroleum: Bull. California State Mining Bureau, No. 31, Sacramento, 1904, sheet.

Cooper, J. G. Lists of fossils from the oil-bearing formations of California. In Watts, W. L., The gas and petroleum-yielding formations of the central valley of California: Bull. California State Mining Bureau, Sacramento, 1894, pp. 7, 10, 25, 38–40, 43, 49, 53–59, 62–65.

———. Lists of fossils from the oil-bearing formations of California. In Watts, W. L., Oil and gas-yielding formations of Los Angeles, Ventura, and Santa Barbara counties: Bull. California State Mining Bureau No. 11, Sacramento, 1897, pp. 79–87.

Crawford, William H., and Hough, Edward S. *See* Hough, Edward S.

Cronise, Titus F. The natural wealth of California. San Francisco, 1868, chap. 6.

Deane, C. T. The oil industry of California from a commercial standpoint: Am. Gas Light Jour., August 31, 1903.

Eldridge, George H. The asphalt and bituminous-rock deposits of the United States: Twenty-second Ann. Rept. U. S. Geol. Survey, pt. 1, Washington, 1901, pp. 209–452, Pls. XXV–LVIII, 52 text figs.

———. Petroleum fields of California. In Contributions to Economic Geology for 1902: Bull. U. S. Geol. Survey, No. 213, Washington, 1903, pp. 306–321.

———. Geology of California oil fields. In The production of petroleum: Mineral Resources U. S. for 1902, U. S. Geol. Survey, Washington, 1903, pp. 202–207.

Fairbanks, H. W. Geology of San Diego County, also portions of Orange and San Bernardino counties: Eleventh Ann. Rept. California State Mining Bureau, Sacramento, 1893, pp. 76–120.

———. Notes on a breathing gas well: Science, new ser., vol. 3, New York, 1896, pp. 693–694.

———. Some notes on the petroleum deposits of California: Min. and Sci. Press, vol. 78, San Francisco, 1899, p. 533.

———. The oil-yielding formations of Monterey, San Luis Obispo and San Benito counties: Bull. California State Mining Bureau, No. 19, Sacramento, 1900, pp. 143–150.

Goodyear, W. A. Petroleum, asphaltum, and natural gas of California, in the counties south of the Bay of San Francisco: Seventh Ann. Rept. California State Mining Bureau, Sacramento, 1888, pp. 63–114.

Hayes, C. W., and Kennedy, William. Oil fields of the Texas-Louisiana gulf coastal plain: Bull. U. S. Geol. Survey No. 212, Washington, 1903, 174 pp., Pls. I–XI, figs. 1–12.

Hough, Edward S., and Crawford, William H. Report of recent oil-burning installations on the Pacific coast: Marine Engineering, September, 1902.

Howard, John L. Fuel conditions in California: Am. Gas Light Jour., August 25, 1902; Jour. Electricity, November, 1902.

Hudson, Ed. J., and Mabery, Charles F. *See* Mabery, Chas. F., 1900–1901.

Hunt, A. M. California petroleum and its use as fuel: Jour. Electricity, May, 1903.

Jackson, C. T. The oil interest of southern California: San Francisco Bulletin, July, 1865.

Kennedy, William, and Hayes, C. W. *See* Hayes, C. W., 1903.

Lakes, A. California asphaltum: Mines and Minerals, vol. 20, Scranton, Pa., 1899, pp. 108–109.

——— Oil fields of California: Mines and Minerals, vol. 21, Scranton, Pa., 1901, pp. 467–470.

Lengfeld, Felix, and O'Neill, Edmond. A study of California petroleum; preliminary notice: Am. Chem. Jour., vol. 15, Baltimore, 1893, pp. 19–21.

Loew, Oscar. Report on the geological and mineralogical character of southeastern California and adjacent regions: Ann. Rept. U. S. Geog. Surv. W. 100th Mer. for 1875–6, Washington, 1876, Appendix H 2, pp. 173–178.

Lyman, B. S. Bibliography of petroleum: U. S. Census Report, 1880, vol. 10, pp. 281 et seq.; Ann. Rept. Geol. Survey Pennsylvania, 1886, p. 2.

Mabery, Charles F. Preliminary paper on the composition of California petroleum: Am. Chem. Jour., vol. 19, Baltimore, 1897, pp. 796–804.

Mabery, Charles A., and Hudson, Ed. J. On the composition of California petroleum: Jour. Soc. Chem. Ind., vol. 19, London, pp. 502–503; Am. Chem. Jour., vol. 25, Baltimore, 1901, pp. 253-297.

Marcou, Jules. Report on the geology of a portion of southern California: Ann. Rept U. S. Geog. Surv. W. 100th Mer. for 1875-6, Washington, 1876, Appendix H 1, pp. 158-172.

Means, John H. Map of the Oil City oil fields, Fresno County: Bull. California State Mining Bureau No. 15, Sacramento, 1899, sheet.

Merriam, J. C. Lists of fossils from the oil-bearing formations of California. In Watts W. L., Oil- and gas-yielding formations of California: Bull. California State Mining Bureau No. 19, Sacramento, 1900, pp. 218-224.

——— Recent discoveries of Quaternary mammals in Southern California: Science, N. S., vol. 24, no. 608, pp. 248-250, August 24, 1906.

Oliphant, F. H. The production of petroleum in the United States: Mineral Resources U. S. for 1900, U. S. Geol. Survey, Washington, 1901, pp. 129-134; idem for 1901, p. 58; idem for 1902, pp. 188-207; idem for 1903, pp. 166-178; idem for 1904, pp. 189-194.

O'Neill, Edmond. Petroleum in California: Am. Gas Light Jour., September 7, 1903.

O'Neill, Edmond, and Lengfeld, Felix. *See* Lengfeld, Felix.

Peckham, S. F. Examination of the bituminous substances occurring in southern California. Geol. Survey, California, vol. 2, 1882, appendix, p. 49-90.

——— Petroleum in southern California: Science, vol. 23, New York, 1894, pp. 74-78.

——— Petroleum in its relations to asphaltic pavements: Am. Jour. Sci., vol. 47, New Haven, Conn., 1894, pp 28-34.

——— On the nitrogen content of California petroleum: Am. Jour. Sci., vol. 48, New Haven, Conn., 1894, pp. 250-255.

——— The asphalt question: Jour. Am. Chem. Soc., vol. 17, No. 1, Baltimore, Jan. 19, 1895, pp. 1-9.

——— On the use of acetone in the technical analysis of asphaltum: Jour. Franklin Inst., vol. 141, Philadelphia, March, 1896, pp. 219-223.

——— On the nature and origin of petroleum: Proc. Am. Phil. Soc., vol. 36, Philadelphia, No. 154, 1897, pp. 1-10.

——— On the sulphur content of bitumens: Jour. Soc. Chem. Ind., vol. 16, No. 12, London, 1897, pp. 1-7.

——— The technology of California bitumens: Jour. Franklin Inst., vol. 146, July, 1898, pp. 45-54.

——— The genesis of bitumens as related to chemical geology: Proc. Am. Phil. Soc., vol. 37, No. 157, Philadelphia, 1898, pp. 108-139.

——— On the classification of crude petroleum: Jour. Franklin Inst., vol. 151, Feb., 1901, pp. 114-124.

Peckham, S. F. and H. E. The determination of sulphur in bitumens: Jour. Am. Chem. Soc., vol. 21, No. 9, Sept., 1899, pp. 772-776.

Prutzman, Paul W. Production and use of petroleum in California: Bull. California State Mining Bureau No. 32, Sacramento, 1904, 230 pp., 54 text figs. and maps, 25 tables, 64 half-tones.

——— Oil wells in Kern County. In Register of mines and minerals, Kern County: Register California State Mining Bureau, Sacramento, 1904, pp. 20-22, 4 maps.

Richardson, Clifford. Petroleum from the Olinda field: Jour. Soc. Chem. Ind., vol. 19, London, 1900, pp. 123-124.

——— The petroleums of North America. A comparison of the character of those of the older and newer fields: Jour. Franklin Inst., vol. 16, 1906, pp. 57-70, 81-128. California fields, pp. 91-106.

Ropp, Alfred von der. The use of crude oil in smelting: Min. and Sci. Press, November 29, 1902; Eng. and Min. Jour., January 10, 1903 (abstract).

Salathe, Frederick. Résumé of original researches, analyses, and refining methods of petroleum, mainly from the southern counties of California: Thirteenth Ann. Rept. California State Mining Bureau, Sacramento, 1896, pp. 656-661; Bull. California State Mining Bureau No. 11, Sacramento, 1897, pp. 73–78.

Sheedy, P. The use of oil fuel on the Southern Pacific: Am. Engr. and R. R. Jour., July, 1902.

Silliman, Benjamin. A description of the recently discovered petroleum region in California, with a report on the same. New York, 1865, 24 pp., 1 pl.

——— Report upon the oil property of the Philadelphia and California Petroleum Company. Philadelphia, 1865, 36 pp.

——— On petroleum in California: National Intelligencer, February 7, 1866.

——— On naphtha and illuminating oil from heavy California tar (maltha): Am. Jour. Sci., 2d ser., vol. 43, New Haven, Conn., 1867, pp. 242–246.

State Mineralogist. Petroleum and allied products: Second Ann. Rept. California State Mining Bureau, Sacramento, 1882, p. 26: Fourth Ann. Rept., 1884, pp. 278–308; Fifth Ann. Rept., 1885, pp. 102–103; Seventh Ann. Rept., 1888, pp. 10–56; Eighth Ann. Rept., 1889, pp. 25, 26, 159, 216, 339–341, 349, 404, 483, 530, 534, 538, 547, 550, 554, 678, 686; Ninth Ann. Rept., 1890, pp. 55–56, 332; Tenth Ann. Rept., 1890, pp. 140, 163–164, 189, 207, 314, 586–588, 606, 622; Eleventh Ann. Rept., 1893, pp. 31, 227, 237, 259, 371–372; Twelfth Ann. Rept., 1894, pp. 26–33, 348–358; Thirteenth Ann. Rept., 1896, pp. 35–45, 567–593.

Strong, A. M., and Arnold, Ralph. *See* Arnold, Ralph, 1905.

Vogdes, Anthony W. A bibliography relating to the geology, paleontology, and mineral resources of California: Bull. California State Mining Bureau No. 10, Sacramento, 1896, 121 pp.; Bull. California State Mining Bureau No. 30, Sacramento, 1904, 290 pp.

Watts, W. L. The gas- and petroleum-yielding formations of the central valley of California: Bull. California State Mining Bureau No. 3, Sacramento, 1894, 100 pp., maps, text figs., and half-tones.

——— Petroleum in California: Thirteenth Ann. Rept. California State Mining Bureau, Sacramento, 1896, pp. 570–593.

——— Oil as fuel in Los Angeles: Thirteenth Ann. Rept. California State Mining Bureau, Sacramento, 1896, pp. 662–664.

——— Oil- and gas-yielding formations of Los Angeles, Ventura, and Santa Barbara counties: Bull. California State Mining Bureau No. 11, Sacramento, 1897, +94 pp., 35 figs.

——— Petroleum in California: California Mines and Minerals, San Francisco, 1899, pp. 188–205, 18 figs.

——— Notes on the oil-yielding formations of California: Min. and Sci. Press, vol. 74, San Francisco, 1899, pp. 144–146, 172–173.

——— Oil- and gas-yielding formations of California: Bull. California State Mining Bureau No. 19, Sacramento, 1900, 236 pp., 26 text figs., 35 half-tones, 13 maps.

Weber, A. H. Natural gas in California: Seventh Ann. Rept. California State Mining Bureau, Sacramento, 1888, pp. 179–191.

——— Petroleum and asphaltum in portions of northern California: Seventh Ann. Rept. California State Mining Bureau, Sacramento, 1888, pp. 193–202.

Whitney, J. D. Geology of the Coast Ranges south of the Bay of Monterey and from the vicinity of Los Angeles, south: Geol. Survey California, Geol., vol. 1, Philadelphia, 1865, pp. 114–186.

Young, W. G. The present condition of the oil industry of California: Eng. and Min. Jour., October 25, 1902.

PHYSICAL AND CHEMICAL PROPERTIES OF SOUTHERN CALIFORNIA OILS.

Compiled by Ralph Arnold.

INTRODUCTION.

The United States Geological Survey has done very little in determining the properties and composition of the California oils, and the information here given is compiled from published reports or the work of private individuals. By far the greater part of the analyses were made by members of the scientific staff of the California State Mining Bureau and are published in bulletins Nos. 3, 11, 19, 31, and 32 of that bureau. The writer is largely indebted for data to Messrs. W. L. Watts, Frederick Salathè, H. N. Cooper, and Paul W. Prutzman. (See bibliography for list of papers, etc.)

GENERAL CHARACTER OF THE SOUTHERN CALIFORNIA OILS.

GRAVITY.

The gravity of the oil from the wells in the Santa Clara Valley, Los Angeles, and Puente Hills districts varies from 10° to over 50° B. The heaviest oils are found in the Los Angeles field; the lightest oil is that from the unique wells in the gneiss of Placerita Canyon, east of Newhall. Certain wells in the Miocene shale of the Puente and Olinda fields (Puente Hills district) and the fields south of Sulphur and San Cayetano mountains (Santa Clara Valley district) yield oil of 30° to 35° gravity, while that in some of the wells in the Pico field (Santa Clara Valley district) is said to go as high as 40°. The greater part of the production from southern California, however, is oil varying from 18° to 24°.

COLOR.

The crude oils from these districts are mostly black or brownish in color. The exceptions are the white oil of the Placerita Canyon wells, Santa Clara Valley district, and the greenish, light-gravity oils of the Sulphur Mountain and Pico Canyon fields, Santa Clara Valley district, and the Puente and Olinda fields, Puente Hills district. Greenish oil is also reported in one or two other instances.

COMPOSITION.

The following table gives the ultimate chemical composition of two California oils and, for comparison, of oils from Pennsylvania, Ohio, West Virginia, and Texas:

Ultimate composition of various crude oils.

Locality.	Specific gravity.	Nearest degree, Baumé.	C.	H.	O.	N.	S.	By whom analyzed.
Oil Creek, Pa.[a]	0.730	62	82.0	14.8	3.2	....	......	Deville.
Ohio[b]	....	....	85.0	13.8	0.60		0.60	
West Virginia[a]	.840	36	84.3	14.1	1.6	....	......	Do.
Beaumont, Tex.[b]	....	....	85.03	12.30	0.92		1.75	
California[a]	....	....	86.934	11.817	......	1.1095	......	Peckham.
California[a] [c]	.912	23.5	84.0	12.7	1.2	1.7	0.4	Salathè.

[a] Watts, W. L., Bull. California State Mining Bureau, No. 19, 1900, p. 207.
[b] Jour. Soc. Chem. Ind., vol. 20, pp. 161 *et seq.*
[c] Mixture of Ventura County oils.

FUEL AND GAS MAKING.

Oil is now largely used as a fuel in California in many places where coal was formerly employed, and is, in a measure, supplanting that commodity. The railroads and those electric lines not using power developed by water use oil almost entirely for fuel purposes. The gas companies also use it for the manufacture of gas, smelters for the smelting of ores, foundries for the heating and melting of metals, and other manufactories for nearly every purpose requiring the generation of heat.

Following is an analysis of a typical gas-producing oil from the Murphy Oil Company's wells, Whittier district, and an analysis of the gas derived from it:[a]

Results of crude oil test, Murphy Oil Company.

Gravity at 60° F .... °B..	20.5
Moisture and nonpetroleum substances[b]	None.
Flash point.[b]	
Sulphur .... per cent..	0.05
Residue (dry lampblack) .... do....	.01

Analysis of the gas produced from Murphy Oil Company's crude oil.

[Based on the Lowe process—18-candlepower gas; 1,800 B. T. U.]

Carbonic acid (CO_2)	None.	Marsh gas (CH_4)	41.8
Illuminants	11.2	Nitrogen (N)	2.8
Oxygen (O)	.4		
Carbonic oxide (CO)	3.4		99.6
Hydrogen (H)	40		

This gas gave over 600 British thermal units per cubic foot. It took 7.75 gallons of crude oil to produce 1,000 cubic feet of gas.

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[a] Furnished by Mr. E. A. Bacon, of the Murphy Oil Company, Whittier.
[b] Oil stored in tank eight months. Flash point in oil coming directly from well, in five tests, 130°, 88°, 90°, 92°, 94°.

PRODUCTS OF REFINERIES.

Sixteen refineries use the oil from the three districts under discussion, and as the natural product varies in gravity from 10° to 35° or 40°, the resultant distillates are varied. The higher-grade oil produces gasoline, benzine, kerosene ("water white"), No. 1 and No. 2 distillates, stove distillate, and a residuum of fuel and road oil. The heavier oils, those under 21° or 22°, yield No. 1 and No. 2 distillates, stove distillate, lubricating, fuel, and road oils, with a residuum of asphalt.

The No. 1 and No. 2 distillates are used mostly in gas engines in many places for irrigation plants. No. 1 is suitable for engines under 15 horsepower; No. 2 is best suited to the larger engines. The stove distillate is used in hotels, bakeries, and similar places where the fluid is consumed without steam pressure, while the regular fuel oils are usually forced into the fire boxes by means of special pressure burners.[a]

The following is a list of the principal refinery products, together with the range in gravity of each:

Refined products of California petroleum. [b]

	° B.		° B.
Gasoline	68	Fuel distillate	28–24
Benzine	62	Neutral oils	24–22
Engine distillate	56–40	Light lubricants	24–20
Kerosene	44–40	Engine oils	20–18
Stove oil	35–32	Cylinder oils	18–15
Gas oil	30–28	Crude lubricants, car oil, etc	17–15

ANALYSES.

The following tables give, in a condensed form, the results of a large number of analyses and tests of oils from all the principal fields in the Santa Clara Valley, Los Angeles, and Puente Hills districts. The compiler wishes to reiterate the acknowledgment of his indebtedness to the California State Mining Bureau for the very free use he has made of its publications. The text of Bulletin No. 31[c] of that bureau, is here copied in its entirety to explain Table 1 which is a part of that bulletin.

If a sample of ore containing gold and silver is sent to an assayer he will doubtless report practically the same results as would another assayer who had used an entirely different method of assaying. The same is true of two chemists determining the quantity of sulphur in pyrites, etc. But in organic analysis two different methods may vary as much as 10 per cent, from which it is obvious that data on oil given without the methods by which or the apparatus in which they have been obtained are almost useless and can not be duplicated or proved correct by another chemist. For this reason it is considered proper to give the following description of the methods by which the data in the above table were determined.

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[a] See Prutzman, Paul W., Bull. California State Mining Bureau No. 32, 1904, pp. 58 et seq.

[b] Prutzman, Paul W., Bull. California State Mining Bureau No. 32, 1904, p. 187.

[c] By H. N. Cooper, 1904.

Specific gravity.—Two pycnometers were used, one holding 25 c. c. and the other 1½ c. c., the larger one for the light oils and the smaller for the heavy oils. Both were calibrated with pure distilled water and the water content calculated to 4°. A heavy oil may be introduced into either pycnometer by first filling a small beaker and allowing a very small drop to fall into the pycnometer. This drop will carry with it a thread of oil, which may be increased to a stream, and thus the pycnometer can be filled without getting any air bubbles mixed with the oil. If the oil once touches the side of the neck it is an interminable job to fill the instrument. It would be better to clean out with gasoline and start over again. If the oil is too thick to pour, as above, then use the little pycnometer, which is nothing more than a little bottle with a wide neck and a glass stopper carefully ground in. The little bottle is put next to the lip of the beaker containing the sample and the oil allowed to drain in. If the draining takes place slowly no air will get mixed with the oil. Then the stopper is slowly squeezed in, until by turning it, it grates on the ground glass of the bottle. The excess oil is wiped off with a rag, without undue handling of the bottle with the fingers. After weighing, the temperature is taken with an accurate thermometer and a correction of 0.0006 in specific gravity made for heavy oils and 0.0007 for light oils for each degree centigrade variation from 15°—15° being taken as normal.

Example: The little pycnometer full of sample No. 31 weighs 6.6195 at 18.5°.

6.6195 wt. of pycnometer and oil.
4.8413 wt. of pycnometer.

1.7782 wt. of oil in pycnometer.
1.7782 (wt. of oil) ÷ 1.8431 (wt. of water) = .9648.
.9648 + (3½ × .0006) = .9669 sp. g. of No. 31 at 15°.

This seems a long process, but it is quickly carried out. I made 16 specific-gravity determinations in four hours, or an average of 1 in fifteen minutes. An error in the specific gravity causes a corresponding error in the distillation and also in the calorific value per c. c., and too much care can not be taken in its determination. To take the gravity of heavy oils by the hydrometer is as long as this, and, moreover, very inaccurate. On first consideration it might seem that the specific gravity taken in a little bottle as small as 1.5 c. c. would be inaccurate, but I compared this with the 25 c. c. pycnometer and obtained results agreeing to 0.0001 in specific gravity, or practically identical.

Viscosity.—There are many viscometers, but none of them are ideal. Nevertheless, I could not invent one that would answer all requirements and expect the public to use it. It takes time to introduce a new idea or instrument. The Redwood viscometer seems to me to be the best now on the market, for the following reasons: It is the English standard; the tip is made of agate, and so will not wear out; the tip is surrounded by heavy brass, thus keeping the oil in the tip at approximately the same temperature as the oil in the cup.

In the above data the viscosity has been taken at two temperatures—at 15° C. (about 60° F.) and at 85° C. (185° F.). It was taken at 15° C. because this is generally taken as "ordinary temperature," and at 85° C. because it is impossible to heat the contents of the Redwood viscometer up to 100° C. (212° F.) with boiling water, so some lower temperature must be chosen. It is easy to heat the instrument up to 85° C. (185° F.), and, moreover, a pipe line may be heated to 85° C., but with great difficulty higher than this. Since our main object in finding the viscosity is to ascertain whether the oil can be piped without too great cost for pumping, the last consideration is important. To see whether it is practical to pass the oil through pipes 85° C. has been chosen.

It is customary to give the results in the number of seconds that it takes 50 c. c. to run through the instrument. To compare this with water (which runs through in 25 seconds) the results must be divided by 25. Through the instrument which I used water ran in 27½ seconds. Therefore I give two sets of results; one set consists of the number of seconds it took the oil to run through the instrument which I used; the other set, the same number of seconds divided by 27½. The data of the last set approximately tell how many more times viscous the oil is than water at 15° C. (about 60° F.). Just before the test is made the level of the oil is made even with the tip.

Flash point.—Nothing can be more inaccurate than the open tester, since it may be manipulated at will to give results varying by 10°. The most accurate of the open testers is liable to great variations in its results from drafts of air. The Abel closed tester gives results which may be duplicated within 1° or 2°. It is the English standard, and with the Pensky attachment it is the German standard. It seems to be perfect in every respect for its purpose, i. e., for determining the flash from 60° F. to 160° F. (Why not adopt it as the standard for California?) If the instructions for opening the slide are carefully followed, the Pensky clockwork for opening the slide is not necessary; it was invented to do away entirely with any tampering with results. In making the above determinations of flash point the directions given in Redwood's Manual were followed exactly. Since the flash was taken with reference to safety in transportation, the test was not made on those samples flashing below 15° C. (60° F.) and above 70° C. (168° F.).

Calorific value.—All the determinations were made with the Atwater bomb. The thermometer used was a Beckman, graduated in one one-hundredths, whose accuracy I tested. The basis was the average between Berthelot's calorific values for cane sugar and naphthalene. I carefully determined the value of these two substances. The naphthalene used was made by De Häen, Germany; its boiling point was between 79° and 80°, and it was melted before using. The sugar was three times crystallized cane sugar, whose composition by organic combustion agreed with the theoretical by 0.03 on the H and 0.05 on the C; in other words, perfectly pure sugar. Before using, it was dried at 50° in the oven. My average of several results on sugar and naphthalene had to be increased by 1.08 per cent to make it the same as Berthelot's average for sugar and naphthalene, and all my results on petroleum are increased by the factor 1.0108, which is evidently the correction factor of the bomb calorimeter plus my personal equation. My results are certainly within 0.5 per cent of the absolute, and on repetition the duplicates agree within 0.3 per cent.

Samples Nos. 1, 2, 3, 4, 6, 7, 9, 10, 14, 17, 19, 25, 29, 38, 40, 41, 42, 43, 46, and 48 were taken from the top of the cans after the oil had stood for three or four months, and the calorific value found without preliminary treatment. Since Nos. 3, 4, 17, 29, and 40 had water present, the calorific value obtained for these was increased by the same number of per cent as the oil held water; in other words, the calorific value was calculated on the dry sample. All other calorific values that were made of samples containing water first had the water removed by distillation. The calorific value of an oil containing water is useless for most purposes unless the percentage of water is given also; for how can anyone get concordant results on a sample half water? (See sample No. 30.) Oil is bought by the gallon and not by the pound, and the column headed "Calorific value per c. c." gives the comparative value of the oils by volume.

Sulphur.—The sulphur was determined from the sulphuric acid left over from the combustion in the platinum cup. The cup or lining as well as the lid of the bomb was carefully washed into a beaker, the liquid filtered to about 100 c. c., $BaCl_2$ added, and the precipitated $BaSO_4$ weighed and the sulphur calculated. The gases of combustion I found to contain no sulphuric acid. (And of course no SO_2, since HNO_3 was present.) I passed the gases slowly through glass wool soaked in $\frac{N}{10}$ KOH, and found almost no consumption of the alkalinity of the KOH, showing that all the H_2SO_4 and HNO_3 stuck to the lining.

Distillation.—An ordinary ½-liter glass distilling flask was used. The exit tube is bent upward for 2 inches just after leaving the neck of the flask; this is to facilitate filling and to intercept any liquid spurted out during the distillation. I do not give the measurements of the flask, because in California we have to take what we can get in the line of glassware. But if the flask holds 300 to 325 c. c. up to the bottom of the neck, the diameter of the neck is about one-fifth the diameter of the bulb, the exit tube joined to the neck halfway between the top of the bulb and the top of the neck, and the neck about one and one-half times as long as the diameter of the bulb, the flask will fulfill the requirements. To prevent condensation in the upward bend it is surrounded by fluffed asbestos fiber about half an inch thick. The exit tube should be 30 inches long from the top of the bend to the tip of the tube. The thermometer is placed so that the top of the bulb is level with the bottom of the exit tube. During the distillation up to the 250°-300° fraction the exit tube passes through a water condenser. After this fraction passes over the condenser is removed and the exit tube used as an air condenser.

The specific gravity of the sample is first determined; then the flask is placed on one pan and counterbalanced with shot. The balance must be accurate to 50 mg. with a 300-gram load. Enough oil is poured in to make a volume of 200 c. c. (calculated from the specific gravity) at the temperature of the room in which the distillation is to take place. The condenser is attached, the 50-c. c. graduated cylinder put under the tip of the exit tube, and the oil is cautiously heated until all the water is driven over. In making the fractional distillation I do not recommend putting in any measured amount of gasoline or other light-boiling liquid to drive off the water. I have never seen a sample that could not be fractionated in its original condition, if care and patience are used. The oil is then fractionated between the following temperatures: Up to 100°, 100°-150°, 150°-200°, 200°-250°, 250°-300°, 300°-asphalt, asphalt. The flame is so regulated as to cause the oil to distill over no faster than two drops per second. Just before the thermometer reaches the point where the distillation is to be stopped the flame is moderated to allow the thermometer to rise gradually to the stopping point. The flame is now removed to allow the temperature to fall, 20° for the 100° fraction, 100° for the 300° fraction, and a proportionate fall for the fractions in between, and then heated up again. This is repeated until no more than three drops can be squeezed over. The receiver is then changed and the next higher distillate run over. An exception must be made with the 250°-300° fraction, if much cracking takes place. With some oils very varying results may be obtained for the 250°-300° fraction, because every time the temperature goes up to 300° cracking takes place and more distillate passes over. In such cases I have arbitrarily stopped at 50 c. c. and made a note to that effect in the tables (the fraction is marked [*b*]), or else I have kept the temperature at 290° until the cracking had almost stopped. This last procedure is too long to be practical, and I recommend the former. The asphalt was run down to grade D. It was tested by running a looped wire down the neck of the distilling flask, drawing out a drop and testing it by chewing or by the finger nail. Of course, with such small quantities it does not make much difference in the results whether the asphalt is run down to grade C, D, or E. The asphalt is measured in this way: Fill the flask with water to a mark on the neck; pour out the water and save for future use. Dissolve the asphalt in waste lubricating oil (heat the flask over the flame) and remove the traces with gasoline and then with hot sulphuric acid and potassium bichromate. Dry, and pour back the water. Now run in water from a burette to the mark. The number of cubic centimeters run in represents the asphalt.

TABLE 1.—*Chemical analyses of southern California petroleum.*[a]

[By H. N. Cooper, chemist. All samples taken direct from pump by Marion Aubury, field assistant, California State Mining Bureau.]

No. of sample.	Name of company.	County.	Location.	Field.	Elevation.	Shipping station.	Address.	Number or name of well.	Formation.	Depth of well.	Daily yield.	Total amount produced.
	SANTA CLARA VALLEY DISTRICT.				*Feet.*					*Feet.*	*Bbls.*	*Bbls.*
1	Union Oil Co. of California.	Ventura	Rancho Ex-Mission	Adams Canyon		Santa Paula	Los Angeles	No. 27	Sand	2,745	35	
2	do	do	do	do		do	do	Green Oil Tunnel.	Sand and shale.			
3	do	do	do	Salt Marsh Canyon.		do	do	No. 11	Sand	520	100	
4	do	do	Sec. 12, T. 3 N., R. 20 W.	Bardsdale Canyon.		Ventura	do	Robinson No. 2.	Red and white sand.	685	25	
5	Burrows & Sons	do	11 miles northwest of Santa Paula.	Wheeler Canyon	1,010	do	Santa Paula	No. 6	Sand	958	20	1,800
6	do	do	do	do	1,300	Santa Paula	do	Garrett Tunnel	do	640	3½	
7	Westlake-Rommell Oil Co.	do	Secs. 17 and 18, T. 4 N., R. 21 W.	Silver Thread	1,350	do	Los Angeles	Old No. 6	Sand and shale.	1,000	3–5	
8	Los Angeles Pacific Rwy. Co.	do	Sec. 16, T. 4 N., R. 21 W.	do	1,375	do	do	Capital Crude No. 20.	do	1,000	30	2,000
9	Whidden-Double	do	NW. ¼ sec. 12, T. 4 N., R. 22 W.	Ojai	1,450	do	Santa Paula	No. 4	Sand	284	16	2,000
10	Los Angeles Pacific Rwy. Co.	do	Sec. 18, T. 4 N., R. 20 W.	Timber Canyon	2,500	do	Los Angeles	Timber Canyon No. 3.	do	1,180	12	4,500
11	Union Oil Co. of California.	do	Sec. 6, T. 4 N., R. 19 W.	Little Sespe Canyon.	1,000	Ventura	do	No. 7	do	1,175	15	
12	Sulphur Mountain Petroleum Co.	do	15 miles northwest of Santa Paula.	Sulphur Mountain.	2,500		Fullerton	No. 1	do	2,150	18	300
13	Buckhorn Oil and Transportation Co.	do	Sec. 13, T. 4 N., R. 19 W.	Hopper Canyon	1,100	Buckhorn	Buckhorn	No. 15	Sand and shale.	950	20	
14	Union Oil Co. of California.	do		Torrey Canyon	1,650	Ventura and Santa Paula.	Los Angeles	No. 52	do	1,410	13	
15	Modelo Oil Co	do	Sec. 8, T. 4 N., R. 18 W.	Modelo Canyon	2,350	Piru	Piru	No. 22	Sand	1,100	15	
16	Santa Ana Oil Co	Los Angeles		Elsmere Canyon	1,500	Newhall	Santa Ana	Santa Ana No. 2	do	1,000	40	
17	Pearl Oil Co	do	Sec. 13, T. 4 S., R. 16 W.	San Fernando	1,500	do	Los Angeles	Pearl No. 2	Gravelly sand.	662	18	
18	Santa Ana Oil Co	do		Elsmere Canyon	1,300	do	Santa Ana	Santa No. 2	do	1,000	40	
19	Pacific Coast Oil Co	do	Sec. 2, T. 3 N., R. 17 W.	Pico Canyon	1,900	Ventura	Newhall	No. 4	Sand and shale.	1,400		

[a] Bull. California State Mining Bureau, No. 31, 1904.

TABLE 1.—*Chemical analyses of southern California petroleum*—Continued.

No. of sample.	Name of company.	County.	Location.	Field.	Elevation.	Shipping station.	Address.	Number or name of well.	Formation.	Depth of well.	Daily yield.	Total amount produced.
	SANTA CLARA VALLEY DISTRICT—cont'd.				*Feet.*					*Feet.*	*Bbls.*	*Bbls.*
20	Pacific Coast Oil Co.	Los Angeles	Sec. 7, T. 3 N., R. 15 W.	Elsmere Canyon	1,400	Newhall	Los Angeles	No. 2	Sand and shale.	1,000	......	......
21	do	do	Sec. 16, T. 3 N., R. 16 W.	Wiley Canyon	1,700	Ventura	do	No. 6	do	750	......	......
	LOS ANGELES DISTRICT.											
22	I. W. Shirley	Los Angeles	......	Central	......	Los Angeles	Los Angeles	No. 12	Sand	1,340	10	......
23	Proudfit & Parker	do	......	Eastern	200	do	do	No. 2	do	1,225	20	......
24	Davis & Harrison	do	......	do	440	do	do	No. 10	do	1,275	10	8,000
25	do	do	......	do	440	do	do	Solano	do	950	4	6,000
26	M. Manley & Co.	do	......	do	360	do	do	Saunders	do	1,035	3	20,000
27	West Lake Oil Co.	do	......	Western	250	do	do	No. 7	do	370	1-3	15,000
28	Los Angeles Rwy. Co.	do	......	do	250	do	do	Hubbel No. 2	Sand and shale.	1,250	10	10,950
29	Park Crude Oil Co.	do	......	Central	425	do	do	No. 13	Sand	1,060	5	5,000
30	E. A. Clampitt	do	......	do	435	do	do	Clampitt No. 1	do	1,080	50	10,000
31	Consolidated Crude Oil Co.	do	......	Eastern	265	do	do	No. 21	do	800	4	......
32	Salt Lake Oil Co.	do	......	Salt Lake	200	do	do	No. 4	do	1,284	40	......
33	La Brea Rancho Oil and Asphalt Co.	do	......	Western	200	do	do	No. 14	do	410	6	......
	PUENTE HILLS DISTRICT.											
34	Whittier-Fillmore Oil Co.	Los Angeles	SE. ¼ sec. 22, T. 2 S., R. 11 W.	Whittier	950	Whittier	Whittier	No. 1	Sand	2,300	65	......
35	Union Oil Co.	do	Sansinena Ranch	La Habra	......	......	Los Angeles	No. 5	do	1,500	......	......
36	Puente Oil Co.	do	T. 2 S., R. 11 W.	Puente	1,200	Chino	do	No. 66	do	1,425	25	......
37	Home Oil Co.	do	Sec. 22, T. 2 S., R. 11 W.	Whittier	900	Whittier	Whittier	......	do	1,713	40	5,000
38	Central Oil Co. of Los Angeles.	do	Sec. 23, T. 2 S., R. 11 W.	do	450	Los Nietos	Los Angeles	......	do	1,856	105	28,342
39	Columbia Oil and Producing Co.	Orange	......	Olinda	......	Olinda	do	......	do	680	25	......
40	Santa Fe	do	Sec. 8, T. 3 S., R. 19 W.	do	535	do	Olinda	......	do	2,404	300	206,744
41	do	do	Sec. 9, T. 3 S., R. 9 W.	do	610	do	do	No. 39	Sand and shale.	1,705	90	4,473
42	Brea Canyon Oil Co.	do	......	Brea Canyon	710	Norwalk	Los Angeles	No. 12	do	1,515	400	300,000

No. of sample.	Time operated.	Depth to oil sand.	Thickness of oil sand.	Pipe line.	Gravity.	Specific gravity of crude at 15° C. (about 60° F.).	Flash.	Viscosity. At 15° C. (about 60° F.). Seconds.	Viscosity. At 15° C. (about 60° F.). Seconds divided by 27½ or water=1.	Viscosity. At 85° C. (185° F.). Seconds.	Viscosity. At 85° C. (185° F.). Seconds divided by 27½ or water=1.	Sulphur.	Calorific value of dry sample. (To convert calories into British thermal units multiply by 1.8.)	Calorific value per cubic centimeter.
		Feet.	*Feet.*		° *B.*		°					*Per cent.*		
1	Since Sept. 9, 1891	600		10 miles	28.9	0.8814	−15	162½	5.91	37	1.34	0.48	10,647	9,384
2	15 years				20.1	.9326	68	247	8.95	38½	1.40	.32	10,604	9,889
3	Since May 14, 1897	48		10 miles	19.7	.9351	−15	878	31.82	55	1.98			
4	11 years	525	160	30 miles	27.6	.8881	−15	205	7.43	41⅞	1.51	1.74	10,484	9,310
5	Since Mar. 11, 1903	500	4–50	27 miles	29.7	.8767	−15	77	2.79	34⅛	1.24	.72	10,645	9,332
6	18 years	90, 200		do	28.6	.8828	29	53	1.92	31⅞	1.15			
7	35 years	600	80, 100, 105											
8	Since Sept., 1902	400–500	100, 200	7 miles	27.3	.8900	−15	61⅞	2.23	34½	1.24			
9	Since Aug., 1900	240		2½ miles	13.4	.9759	56	+1,800	+65	252	9.13	1.48	9,112	8,892
10	18 months	860, 1,100	60	7 miles	35.1	.8481	−15	45⅛	1.66	31⅛	1.13			
11	5 years	1,010	165	30 miles	30.9	.8701	−15	77	2.79	45⅛	1.66			
12	Since Apr. 27, 1903	1,975		No line	17.6	.9486	−15	2,240	81.15	73	2.65	1.46	10,306	9,776
13	3 years	80	10–50	2½ miles	14.6	.9685	+70	+1,800	+65	116	4.20			
14	do	900	510	30 miles	29.9	.8758	−15	103	3.73	38	1.38	.71	10,611	9,293
15	Since July, 1902	600	100	4 miles	28.4	.8838	−15	63	2.28	34	1.23			
16	2 years	930	60–120	2½ miles to Newhall	11.7	.9879	+70	+1,800	+65	131	4.75	.69	10,287	10,139
17	1 year	600	35		17.8	.9474	35½	1,335	48.37	58	2.10	.49	10,461	9,911
18	2 years	930	60–120	2½ miles to Newhall	14.5	.9687	+70	+1,800	+65	131	4.75	.72	10,368	10,044
19				45 miles	37.3	.8367	−15	38½	1.40	29½	1.07	.28	11,141	9,322
20	10 years			1½ miles	14.8	.9666	+70	+1,800	+65	114	4.13	.62	10,389	10,042
21				50 miles	29.9	.8758	−15	61	2.21	33½	1.22			
22	7 years	1,000	340	30 miles	16.5	.9559	+70	+1,800	+65	78	2.83	.85	10,437	9,976
23	1 year	750	10–100	No line	14.3	.9699	+70	+1,800	+65	130	4.71			
24	5 years	800	10–75	do	13.2	.9774	+70	+1,800	+65	330	11.96	.49	10,091	9,863
25	do	800	100	do	17.9	.9467	+70	1,700	61.59	55	1.99			
26	9 years	900	200	Union pipe line								[a].74	[b]9,016	
27	4 years	315	55	No line	12	.9860	+70	+1,800	+65	540	19.57			
28	3 years	800	10–20	do	16.5	.9558	+70	+1,800	+65	72	2.61			
29	do	750	1–20	do	14.2	.9706	+70	+1,800	+65	122	4.42	1.18	10,346	10,073
30	2 years	800	80	60 feet to Union line	13.8	.9736	+70	+1,800	+65	149	5.40	1.30	9,920	9,377
31	6 years	750	30–60	No line	12.6	.9815	+70	+1,800	+65	505	18.30			
32	Since Feb. 8, 1892	1,170	40	do	17.6	.9487	−15	2,170	78.63	78	2.83			
33	1 month	305	75	do	10	1.0100	+70	+1,800	+65	±2,700	±97.83			
34	5 months	1,700	20–150	do	14.8	.9669	+70	+1,800	+65	122	4.42	.93	10,409	10,064
35	5 years	1,300	200	Line to San Pedro	15	.9656	67	+1,800	+65	143	5.18			

[a] Not accurate.

TABLE 1.—*Chemical analyses of southern California petroleum*—Continued.

No. of sample.	Time operated.	Depth to oil sand.	Thickness of oil sand.	Pipe line.	Gravity.	Specific gravity of crude at 15° C. (about 60° F.).	Flash.	Viscosity.				Sulphur.	Calorific value of dry sample. (To convert calories into British thermal units multiply by 1.8.)	Calorific value per cubic centimeter.
								At 15° C. (about 60° F.).		At 85° C. (185° F.).				
								Seconds.	Seconds divided by 27½ or water=1.	Seconds.	Seconds divided by 27½ or water=1.			
		Feet.	*Feet.*		° *B.*		°					*Per cent.*		
36	1 year	....	5-15	18 miles to Chino	29.5	.8775	−15	66½	2.35	34	1.23	0.36	10,699	9,389
37	3 months	675	....	2½ miles to Whittier	20.7	.9291	26	393	14.24	43	1.56	....	....	....
38	9 months	1,636	220	4½ miles	21.9	.9215	17	325	11.78	42	1.52	....	....	....
39	Since Feb., 1903	450	230	Union line to San Pedro.	19.3	.9378	−15	1,020	36.96	59½	2.16	....	....	....
40	Since Mar. 4, 1902	....	720	No line	19	.9399	44	1,790	64.85	71	2.57	1.09	10,441	9,813
41	Since May 23, 1903	1,648	57	Olinda Union line	34	.8536	−15	45½	1.61	32½	1.18	.41	10,777	9,200
42	Since Jan. 18, 1902	950	30-133	....	23	.9147	−15	264	9.56	41½	1.50	.94	10,581	9,678

No. of sample.	Distillation.																
	Percentage.										Specific gravity of preceding fractions at 15° C. (about 60° F.).						
	Water.	Up to 100° C.	100°-150° C.	150°-200° C.	200°-250° C.	250°-300° C.	300° C. to asphalt.		Asphalt.	Loss or gain.	Up to 100° C.	100°-150° C.	150°-200° C.	200°-250° C.	250°-300° C.	300° C. to asphalt.	
							A.	B.								A.	B.
1	None.	4	14.1	9.1	9.3	10.1	43	....	9.8	−0.6	0.7250	0.7736	0.8111	0.8388	0.8547	0.8778	....
2	Trace.	0	.8	7.8	16.3	17.4	40	....	16.6	−1.1	....	....	.8083	.8368	.8718	.9013	....
3	None.	1.4	8.7	8.3	8.7	8.9	40.1	....	20.7	−3.2	.7236	.7625	.8103	.8578	.8964	.9156	....
4	None.	8.9	10.6	8.7	7.3	15.5	29	....	16.9	−3.1	.7039	.7611	.8013	.8340	.8631	.8778	....
5	None.	12.8	13.8	9.9	7.7	9.8	30	....	14.8	−1.2	.6986	.7601	.7999	.8466	.8830	.8920	....
6	None.	0	12.3	16.6	14.3	13.7	37.3	....	6.2	+ .4	....	.7798	.8129	.8460	.8787	.9014	....
7	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
8	None.	9.3	16.5	11.8	7.7	9.1	31.8	....	13	− .8	.7228	.7724	.8202	.8613	.8901	.9154	....
9	None.	0	0	6	6.1	18.9	30.8	....	38.1	− .1	....	....	.8102	.8510	.8820	.8925	....
10	None.	15.3	15	9.5	9.9	9.9	28	....	10.6	−1.8	.7002	.7639	.8015	.8321	.8624	.8875	....
11	None.	9.3	10.2	9.8	8.8	11.4	34.9	....	13.2	−2.4	.7057	.7623	.7998	.8285	.8570	.8709	....
12	.8	3.1	4.8	8.1	7.4	[a] 28.8	20	....	25	−2	.7345	.7725	.8178	.8620	.8870	.9302	....
13	9.3	0	0	5.9	15.3	6	23.7	16.7	23	− .1	....	....	.8607	.8888	....	.9156	0.9307

[a] Much cracking on reheating; percentage taken arbitrarily.

14	None.	8.3	10.4	9.1	8.8	10.2	23.9	9.8	16.6	−2.9	.7044	.7674	.8038	.8316	.8554	.8740	.8672
15	None.	7.7	15.6	10.7	10.8	14	15.3	8.9	16.6	− .4	.7119	.7722	.8126	.8493	.8827	.9066	.9644
16	4.2	0	0	0	12.8	16.8	37	6.7	22.6	+ .1	....	....	....	.8611	.8973	.9198	.8933
17	None.	0	1.2	8	11.2	[a]21	24	10.8	22.7	−1.1	....	.7790	.8170	.8618	.8989	.9246	.9087
18	3.5	0	0	0	11.5	12.2	36.5	6.8	28.3	−1.2	....	....	....	.8561	.8962	.9137	.9008
19	None.	10.5	20.4	13.8	13	11.1	16.9	6.8	6.8	− .7	.7472	.7659	.8040	.8359	.8606	.8870	.8720
20	6.1	0	0	0	11.5	[a]22.7	32.1	2.5	22.6	−2.5	....	....	....	.8512	.8970	.9091	.8913
21	None.	2.9	17.4	10.3	10.3	13.5	20.8	9.5	10.9	−4.4	.7297	.7751	.8127	.8409	.8662	.8852	.8929
22	.8	0	0	0	7.6	13.9	40	14.5	21.8	−1.4	....	....	....	.8625	.8849	.9021	.9053
23	.2	0	0	0	4	13.9	42.8	8.3	28.8	−2	....	....	....	.8741	.8908	.9087	.8957
24	30	0	0	0	....	12	30.5	5.8	19.8	−1.9	....	....	....	....	.8912	.9078	.9139
25	.2	0	0	0	6.6	17.5	47.8	9.8	17.3	− .8	....	....	....	.8568	.8855	.9099	.9094
26	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
27	35.7	0	0	0	0	18.6	20.1	2.3	21.3	−2	....	....	....	....	.9029	.9165	.9175
28	.5	0	0	0	9.7	15.8	43.4	8.2	21.5	− .9	....	....	....	.8642	.8980	.9082	.9049
29	1.6	0	0	0	6.9	19.4	39.7	4.5	25.3	−2.6	....	....	....	.8631	.8931	.9200	.9160
30	3	0	0	0	5.9	14.1	47.2	....	28.8	−1	....	....	....	.8637	.8876	.9026	....
31	44.6	0	0	0	4.6	7.7	16.1	9.7	16.2	−1.1	....	....	....	.8642	.8951	.9032	.9177
32	None.	2.9	7.9	7.4	7.8	17	18.2	11.5	26.8	− .5	.7247	.7650	.8175	.8804	.8903	.9051	.8905
33	5	0	0	0	3.7	[a]24.1	20.9	....	44.2	−2.1	....	....	....	.8648	.8882	.9240	....
34	2.3	0	0	0	9.1	19.5	37.6	3.8	26.5	1.2	....	....	....	.8546	.8968	.9180	.9119
35	.2	0	0	5.2	11.6	[a]25.1	28.5	....	28.4	1	....	....	.8197	.8648	.8915	.8910	....
36	None.	8	15.4	9	10.1	14	23.1	5.7	13.1	1.6	.7265	.7720	.8155	.8413	.8648	.8862	.8837
37	None.	0	4.2	9.6	14	14.7	23	16.8	15.7	2	....	.7756	.8313	.8672	.8991	.9210	.9166
38	None.	0	6.9	8.8	12	11.9	33.2	6.2	20.6	.4	....	.7760	.8363	.8557	.8848	.8996	.8796
39	None.	1.9	6.2	9.2	8.1	17.3	27.4	3.8	25.8	.3	.7004	.7627	.8204	.8622	.8876	.9015	.8977
40	1.3	0	0	11.2	10.5	15.5	28.3	9.9	23.1	.2	....	....	.8113	.8551	.8850	.8857	.9001
41	None.	12.9	15.3	11.5	11.1	9.6	19.5	6.5	11	2.6	.7239	.7645	.8044	.8401	.8713	.8955	.8984
42	None.	4.2	13.9	8.9	9.7	18.3	24.2	5	13.3	2.5	.7252	.7701	.8172	.8597	.8937	.8955	.9062

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[a] Much cracking on reheating; percentage taken arbitrarily.

TABLE. 2.—*Proximate analyses of Southern California crude oils.*[a]

[By Paul W. Prutzman.]

No. of sample.	Field.	County.	Section.	Township.	Range.	Taken from—	Gravity (° B.).	Distillation.					
								Below 150° C.		150° C. to 270° C.		Above 270° C.	
								Per cent.	Gravity (° B.).	Per cent.	Gravity (° B.).	Per cent.	Gravity (° B.).
	SANTA CLARA VALLEY DISTRICT.												
1	Elsmere	Los Angeles	13	3 N.	16 W.	Tank	17.2	0	.....	21.9	36.9	50.2	25.5
2	Placerita	....do	4	3 N.	15 W.	Well	42.7	51	48.8	43	38	4	.....
3	Ojai	Ventura	11	4 N.	22 W.	Tank	11.8	0	.....	0	.....	56.6	24.7
4	Torrey	....do	....	....	....	....do	22.6	0	.....	30	38.8	53.2	.....
5	....do	....do	....	....	....	Well	23.9	7.2	54	26.7	38	38.9	.....
6	Santa Paula	....do	....	....	....	....do	25.2	12.5	53.7	25.5	37.6	50.2	23
7	....	....do	....	....	....	Pipe line	25.6	10	58.5	24	41.5	38	29.8
8	Santa Paula	....do	....	....	....	Well	26.	10	56	27	38.8	44	.....
9	Modelo	....do	8	4 N.	18 W.	Tank	26.6	13.8	59.4	32.4	40.8	38.9	.....
10	Santa Paula	....do	....	....	....	Well	26.8	13	54	26.5	39	45.9	.....
11	Silver Thread	....do	17	4 N.	21 W.	Tank	27.4	19.4	50.2	26.1	40.1	35.2	.....
12	Bardsdale	....do	12	3 N.	20 W.	Well	28.	13	61.6	20.5	43.4	40	.....
13	Torrey	....do	....	....	....	....do	28.1	16.6	53.7	23.6	39.8	35.7	.....
	LOS ANGELES DISTRICT.												
14	Los Angeles	Los Angeles	....	....	....	Well	15.1	0	.....	20	30.2	63.7	23
15	....do	....do	....	....	....	....do	15.7	0	.....	17.2	30.2	54.1	.....
	PUENTE HILLS DISTRICT.												
16	Olinda	Orange	8	3 S.	9 W.	Well	15.9	1	.....	14	36.8	41	.....
17	....do	....do	8	3 S.	9 W.	Tank	20.3	Tr.	.....	23	41.2	42.9	.....
18	....do	....do	8	3 S.	9 W.	Well	20.5	3.4	55.8	18.8	39.3	47.6	25.5
19	Brea Canyon	....do	1	3 S.	10 W.	....do	23.3	10.5	57	25.5	39.9	31.4	.....
20	....do	....do	9	3 S.	9 W.	....do	32.4	21.7	59.1	25.8	41.5	41.8	24.7
21	Olinda	....do	9	3 S.	9 W.	....do	32.8	23.8	59.6	27.7	40.7	31.2	.....
22	....do	....do	9	3 S.	9 W.	....do	33.	24.8	60.9	27.6	42.8	31.4	.....
23	....do	....do	9	3 S.	9 W.	....do	33.4	22.1	60.9	30.8	41.3	37.6	.....
24	....do	....do	9	3 S.	9 W.	....do	34.5	22.9	62.1	27.9	43	33.4	26.5
25	Puente	Los Angeles	35	2 S.	10 W.	....do	26.8	10.5	59.2	28	43.6	33	.....
26	....do	....do	35	2 S.	10 W.	....do	26.8	12.5	58.8	29	42.4	63	27.3
27	....do	....do	35	2 S.	10 W.	....do	29.1	21	58.2	24	41.4	30.9	.....
28	Whittier	....do	26	2 S.	11 W.	....do	20.4	0	.....	23.4	38.1	45.3	.....
29	....do	....do	26	2 S.	11 W.	....do	21.	2.1	55	23.9	38.2	48.4	22.6
30	....do	....do	26	2 S.	11 W.	....do	23.1	5.2	55	27.3	38.4	44.7	.....
31	....do	....do	26	2 S.	11 W.	....do	23.2	4.7	57.3	24	39.3	46.9	24.5

[a] Bull. California State Mining Bureau, No. 32, 1904, Table 25, opp. p. 198.

TABLE 2.—*Proximate analyses of Southern California crude oils.*

[By Paul W. Prutzman.]

Distillation.			Calculated analysis.													Remarks.	No. of sample.
Asphalt.		Loss (per cent).	Total. gasoline.		Kerosene.		Middlings.		Lubricants.		Middlings and lubricants (per cent).	Asphalt.			Loss (per cent).		
Per cent.	Grade.		Per cent.	Gravity (° B).	Per cent.	Gravity (° B.).	Per cent.	Gravity (° B).	Per cent.	Gravity (° B.).		Per cent volume.	Per cent weight.	Pounds per barrel.			
25.9	D	2	0.5	....	12.1	40	23.8	.....	35.7	.....	.....	25.9	28.6	94.9	2	.....	1
0	....	2	52.3	49	25.8	40	19.9	.....	0	.....	.....	0	.....	.....	2	White oil.	2
41.7	D	1.7	0	....	0	....	24.3	34.1	32.3	17.5	.....	41.7	44.4	153.1	1.7	.....	3
15.4	D	1.4	1.5	54	19.5	41	.....	.....	.....	.....	62.2	15.4	18.1	56.4	1.4	.....	4
25.5	D	1.7	8	54	16	41	.....	.....	.....	.....	48.8	25.5	29.5	93.6	1.7	.....	5
11.8	D	0	13.3	53	15.3	41	24.5	.....	35.1	.....	.....	11.8	13.7	43.2	0	Green oil.	6
25.3	D	2.7	12.4	57	19.2	42	21.4	.....	19	.....	.....	25.3	29.5	92.9	2.7	.....	7
16	D	3	11.4	55	17.5	41	.....	.....	.....	.....	52.1	16	18.8	59	3	.....	8
12.9	C	2	16.4	59	24.3	42	.....	.....	.....	.....	44.4	12.9	15.2	47.4	2	.....	9
11.1	D	3.5	14.3	53	17.2	41	.....	.....	.....	.....	53.9	11.1	13.1	40.8	3.5	Greenish oil.	10
18.8	D	.5	21.2	58	18.3	42	.....	.....	.....	.....	41.2	18.8	22.1	69	.5	.....	11
25.6	D	.9	15	60	18.5	42	.....	.....	.....	.....	40	25.6	29.1	92.1	.9	.....	12
21.1	D	3	18.3	54	16.5	42	.....	.....	.....	.....	41.1	21.1	25.1	77.7	3	.....	13
13.3	B	3	0	....	4	40	37.2	31.8	42.5	18.7	.....	13.3	13.8	46.7	3	Greenish oil.	14
25.7	D	3	0	....	3	40	.....	.....	.....	.....	68.3	25.7	28.1	93.9	3	.....	15
42	D	2	1.2	....	7.7	40	.....	.....	.....	.....	47.1	42	45.9	154.3	2	.....	16
32.1	D	2	1.8	55	17.9	42	.....	.....	.....	.....	46.2	32.1	36.1	117.9	2	.....	17
25.9	E	4.3	4.4	54	12.3	41	18.4	34	34.7	20.9	.....	25.9	29.2	95.1	4.3	.....	19
31.6	D	1	12.3	56	17.8	42	.....	.....	.....	.....	37.3	31.6	36.3	116.2	1	.....	18
9	D	1.7	24.3	58	20.6	42	15.4	33.7	29	21	.....	9	10.7	32.3	1.7	.....	20
16.7	D	.6	26	59	20.8	42	.....	.....	.....	.....	35.9	16.7	20.5	61.7	.6	.....	21
15.6	D	.6	27.6	60	24.8	42	.....	.....	.....	.....	31.4	15.6	18.1	57.3	.6	.....	22
8	D	1.5	24.6	60	23.1	42	.....	.....	.....	.....	42.8	8	9.6	29	1.5	.....	23
12.9	D	2.9	25.7	61	25.1	42	12.1	32.7	21.3	23	.....	12.9	16	49	2.9	.....	24
26	D	2.5	13.3	58	25.2	42	.....	.....	.....	.....	33	26	30.7	95.7	2.5	.....	25
24	F	1.5	15.4	58	24.7	42	16.4	32.5	18	22.3	.....	24	28.5	88.2	1.5	Mixture from four wells.	26
22.1	D	2	22.9	58	17	42	.....	.....	.....	.....	36	22.1	26.3	81.4	2	.....	27
27.3	D	4	.7	....	14	41	.....	.....	.....	.....	54	27.3	30.8	100.2	4	.....	28
21.4	D	4.2	2.8	54	14.4	41	23.1	31.8	34.1	18.6	.....	21.4	24.2	78.4	4.2	.....	29
20.2	D	2.6	6	55	16.4	41	.....	.....	.....	.....	54.8	20.2	23.2	74.3	2.6	.....	30
19.7	E	4.7	5.9	56	15.6	41	20.6	33.2	33.5	19.5	.....	19.7	22.6	72.3	4.7	.....	31

TABLE 3.—*Distillation tests of southern California crude oils.*[a]

[By W. L. Watts.]

No. of sample.	Well.	Gravity of crude oil (° B.).	Naphtha.						Illuminating oil.				Lubricating oil.			
			100° C.		125° C.		150° C.		200° C.		250° C.		300° C.		350° C.	
			Per cent.	Gravity (° B.).	Per cent.	Gravity (° B.).	Per cent.	Gravity (° B.).	Per cent.	Gravity (° B.).	Per cent.	Gravity (° B.).	Per cent.	Gravity (°B.).	Per cent.	Gravity (° B.).
	SANTA CLARA VALLEY DISTRICT.															
1	Tar Creek	23	......	....	......	....	7.6	60	11	55	10.4	41	12.4	34	6	29
2	.....do	23	......	....	......	....	8.4	63	8	58	10.4	45	14.2	33	4	....
3	Fourfork	22	......	....	......	....	Tr.	....	6.9	52	16.8	45	9.7	38	6.6	33
4	Kentuck	25	......	....	......	....	6	64	8.6	54	10	44	12.2	36	2.5	32
5	Pico Canyon No. 4	40	9.1	69	10.4	59	9.3	54	13.4	48	13.9	41	8.3	35	......	....
	LOS ANGELES DISTRICT.															
6	Central field	17	......	....	......	....	Tr.	....	Tr.	....	8	38	13.6	32	3	....
7	.....do	17	......	....	......	....	Tr.	....	Tr.	....	7	38	15.3	29	7.1	27
8	.....do	17	......	....	......	....	Tr.	....	Tr.	....	6	39	16.8	31	8	27
9	.....do	17	......	....	......	....	Tr.	....	Tr.	....	9.6	40	17.6	36	5	27
10	.....do	17	......	....	......	....	Tr.	....	Tr.	....	8	42	12	32	4	....
11	.....do	16	......	....	......	....	Tr.	....	Tr.	....	1.6	....	11.4	32	3.4	....
12	.....do	16	......	....	......	....	Tr.	....	Tr.	....	2.2	....	11.2	30	7	29
13	Macintosh	13	......	....	......	....	Tr.	....	Tr.	....	Tr.	....	1.6	....	4.4	....
14	Maltman	14	......	....	......	....	......	....	......	....	1	....	8	31	9.6	....
	PUENTE HILLS DISTRICT.															
15	Puente	23	......	....	......	....	Tr.	....	15.9	52	10.8	45	9.3	35	2.9	33
16	.....do	28	......	....	......	....	10.2	61	13.5	55	12.2	43	10.2	36	8.3	34

[a] Bull. California State Mining Bureau No. 19, 1900, pp. 203-205.

TABLE 4.—*Distillation tests of southern California crude oils.*

No. of sample.	Source of sample.	Gravity of crude oil (° B.).	Specific gravity of crude oil at 60° F.	Gasoline (68° B.).		Naphtha or benzine (62° B.).		Engine distillate (56°-40° B.).		Kerosene (44°-40° B.).		Stove oil (35°-32° B.).		Gas oil (30°-28° B.).		Fuel distillate (28°-24° B.).		Lubricants (24°-15° B.).		Asphalt, foreign matter, and loss.
				Per cent.	Gravity (° B.).	Per cent.	Gravity (° B.).	Per cent.	Gravity (° B.).	Per cent.	Gravity (° B.).	Per cent.	Gravity (° B.).	Per cent.	Gravity (° B.).	Per cent.	Gravity (° B.).	Per cent.	Gravity (° B.).	Per cent.
	SANTA CLARA VALLEY DISTRICT.																			
1	Happy Thought wells, Sespe field	26.2								20		12.18		24.48		19.38				22.95
2	....do	26.2		5	66			7	50	12				59						17
3	Sespe field	19.8						6	50			4		55				9		22
4	....do	25.2	0.9022			7.3	60			19.5	42			25	28			35.8	24	12.4
5	Fourfork wells, Sespe field	24	.9090			6	60			17.1	42			29.5	28			34.4	24	13
6	Torrey Canyon	27	.8917			9.2	60			21.5	42			26	28			30.3	24	13
7	Eureka Canyon	29	.8805			14.1	60			26.4	42			24	28			27	24	8.5
8	Adams Canyon, Sulphur Mountain field[a]	24	.9090			5.2	60			24.5	42			17.3	28			46	24	7
9	Ventura County, pipe-line average	26		10.4	63					28	42.5			16.1	28			20.3	23	25.2
10	....do	25.2						14.5	55	13.8	42	14.4	33			22.8	26	16.	21	18.5
	LOS ANGELES DISTRICT.																			
11	Central field	14.3										8.1	35			9.9		42.2		39.7
12	....do	14.2	.9708			Tr.				6	42			17.5	28			51.5	24	25
13	Salt Lake field	19						11		7		8		29				10		35
14	....do	21		4				9		8		7		34				10		28
	PUENTE HILLS DISTRICT.																			
15	Murphy Oil Co.'s wells, Whittier field	21						3.8	59	13.5	43.5	45	33							
16	....do	21						4.5	50	8.7	45	8.9	35			57.1	22-26			20
17	Puente lease, Olinda field	32		8				19.5		12		21.5						29		10

[a] Greenish oil.

1, 2. Furnished by Mr. Herbert Mills, secretary Happy Thought Oil Company, 123 California street, San Francisco.
3, 11, 13, 14, 15, 17. Furnished by Mr. James Jordan, Union Consolidated Refining Company, Los Angeles.
4, 5, 6, 7, 8, 12. Salathé, Frederick, Bull. California State Mining Bureau No. 11, 1897, p. 76.
9, 10. Prutzman, Paul W., Bull. California State Mining Bureau No. 32, 1904, p. 193.

TABLE 5.—*California oil refineries using southern California crude oil.*[a]

Company.	Location of plant.	County.	Still capacity for crude.	Still capacity for rerunning.	Number of stills.	Principal source of crude used.	Products made.
			Barrels.	*Barrels.*			
American Oil and Asphalt Co	Los Angeles	Los Angeles	1,075	0	5	Los Angeles	Distillate and asphalt.
Asphalt and Oil Refining Co	do	do	500	250	5	Fullerton and Coalinga	Light.
British-California Refining Co	do	do	200	200	2	Whittier	Light, distillate, and asphalt.
Coombs Refining Co	do	do	150	150	2		Light, lubricants, and asphalt.
Densmore-Stabler Refining Co	do	do	600	100	5	Various	Do.
Hercules Oil Refining Co	do	do	1,000	1,000	6	Whittier	Do.
Meriden Oil Co	do	do	100	100	2	Los Angeles	Lubricants and asphalt.
New Franklin Oil and Refining Co	do	do	500	135	6	do	Distillate, lubricants, and asphalt.
Pacific Coast Oil Co	Point Richmond	Contra Costa	[b] 5,000	[b] 4,000	[b] 19	Ventura, Newhall, and Coalinga.	Light, lubricants, and coke.
Pacific Oil Refinery	Los Angeles	Los Angeles	30	10	2		Light, lubricants, and asphalt.
Puente Oil Co	Chino	San Bernardino	600	100	5	Puente	Light.
Southern Refining Co	Los Angeles	Los Angeles	500	250	4	Whittier	Light, lubricants, and asphalt.
Sunset Oil Refining Co	Obispo	do	2,400	2,000	16	Whittier and Ventura	Light.
Texas and California Refining Co	Los Angeles	do	450	0	2	Los Angeles	Distillate and asphalt.
Union Consolidated Refining Co	do	do	800	350	6		Light, lubricants, and asphalt.
Union Oil Co	Oleum	Contra Costa	(c)			Ventura, etc	Light, distillate, and asphalt.

[a] Prutzman, Paul W., Bull. California State Mining Bureau, No. 32, 1904, opp. p. 208.
[b] Figures doubtful. Owners refused information.
[c] Owners refused information.

FOSSILS OF THE OIL-BEARING FORMATIONS OF SOUTHERN CALIFORNIA.

By RALPH ARNOLD.

INTRODUCTION.

Many of the oil-bearing rocks of southern California contain the fossil remains of living organisms such as plants, foraminifera, sea urchins or echinoderms, marine and fresh-water mollusks, crabs, fish, and some of the higher vertebrates. The marine mollusks, owing to their peculiar composition and habitat, are relatively much more liable to be preserved in the rocks than the individuals of most of the other groups, and, as a consequence, they are the most abundant of the organic remains, and therefore the most useful for purposes of correlation, not only in this region, but in all regions abounding in marine sediments.

A fossil may be the more or less altered remains of the plant or animal; it may be the empty mold from which all of the original material of the organism has been removed; or it may be the cast of the original form in hardened silt, sand, or some crystallized mineral which has replaced the organism.

It is well known that associations of species (fauna or flora) are governed by two important factors—one of time and the other of environment. The fossil fauna of any formation, unless it be an unusually thick one requiring a very long time for its deposition, is generally fairly constant throughout for rocks of similar lithologic character, owing to the fact that faunas living at approximately the same time, under similar conditions, and in the same general region or biologic province are closely related or nearly identical. Conversely the faunas of the different kinds of rocks in the same formation and even of the same kind of rock in two different formations are always more or less distinct. As the different marine sediments reflect the varying conditions of their deposition, so the faunas reflect their environment; fossils are usually found in a matrix whose deposition was governed by the conditions forming the environment of the fossils. Thus a deep-water fauna is usually found in shale or limestone, a shallow-water or littoral fauna in sandstone or gravel, and so on. Coarse conglomerates, owing to the disturbed conditions surrounding their deposition, rarely contain recognizable fossils.

It follows, then, that similar faunas from two or more different outcrops indicate in a general way the contemporaneity and similarity of conditions of deposition of the beds; that is, they indicate the same horizon or formation. The converse of this statement, however, is not always true, for it often happens, for example, that the shale fauna of one formation bears a stronger affinity to the shale fauna of a second formation either above or below it than to the fauna of contemporaneous sandstone or conglomerate within its own formation.

Some faunas are characterized by the predominance of one or more families or broader groups; some only by the occurrence or abundance of certain species. Analogous to the formations which contain them, certain faunas are distinctly isolated from others of the same region. A formation having an isolated, unique, or so-called characteristic fauna is the most easily identified and correlated, as the determination of only a few of its species often suffices to locate it definitely. The correlation of those rocks whose fauna is not so distinctly separated from the fauna of stratigraphically adjacent formations is much more difficult and generally requires some special training along paleontologic lines. Fortunately most of the formations in southern California contain fairly characteristic faunas, so that with a sufficient amount of identifiable material from any given stratum its correlation, or the determination of its relative position in the stratigraphic column, may be readily approximated.

It is a well-known fact that the only way to determine the relative position or age of any bed in a series where the rocks of the different formations are so much alike and the structure so complex as in the southern California oil districts is by a determination of its fossil contents. Ordinarily lists of fossils are absolutely meaningless except to the few who have devoted at least a little time to the study of paleontology. But when these lists are supplemented by the figures of the species named it is an easy matter for anyone to find out for what each name really stands. The following plates are given to add meaning to the lists of fossils included in the text. The species figured do not represent all of those found in the oil-bearing formations of southern California, but rather those which are commonly found in or are characteristic of the principal formations there developed. It is thought that by means of these figures anyone will be able to locate approximately any bed in the geologic column if he can obtain from it a few recognizable fossils.

The fossils are arranged on the plates in the order of the occurrence of the rocks containing them, beginning with the oldest, the Eocene.

PLATES.

PLATE XXV.

EOCENE PELECYPODA.

(All figures natural size.)

FIG. 1. *Venericardia planicosta* Lamarck. U.S.N.M. 164973. Left valve; longitude 84 mm. Eocene, Little Falls, Wash. This is the most widespread and characteristic Eocene species in the world. Found in the Sespe and Silver Thread districts, Ventura County.

FIG. 1*a*. Same specimen as fig. 1. View of anterior end of both valves.

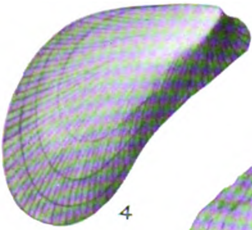
FIG. 1*b*. Same specimen as fig. 1. View of both valves from above.

FIG. 2. *Cardium cooperii* Gabb. U.S.N.M. 164998. A decorticated right valve; longitude 35 mm. Eocene, Rose Canyon, San Diego County. A common species in the Eocene of the west coast.

FIG. 2*a*. Same specimen as fig. 2. View of both valves from above.

FIG. 3. *Meretrix hornii* Gabb. Left valve; longitude 36 mm. Pal. Cal., vol. 2, pl. 30, fig. 78. A common species in the Eocene of the west coast.

FIG. 4. *Modiolus ornatus* Gabb. Right valve; longitude 38 mm. Pal. Cal., vol. 1, pl. 24, fig. 166. Another species found in most Eocene faunas of the west coast.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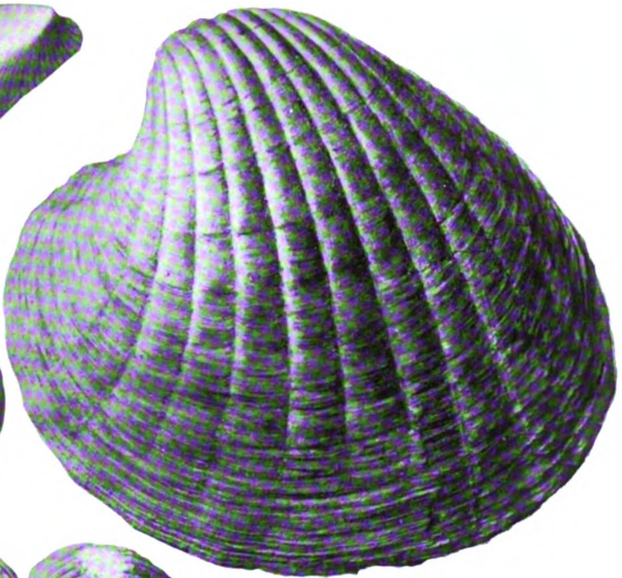
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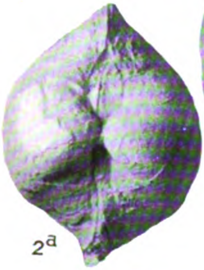
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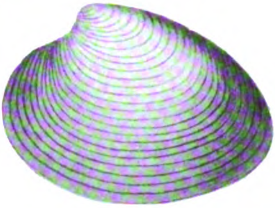
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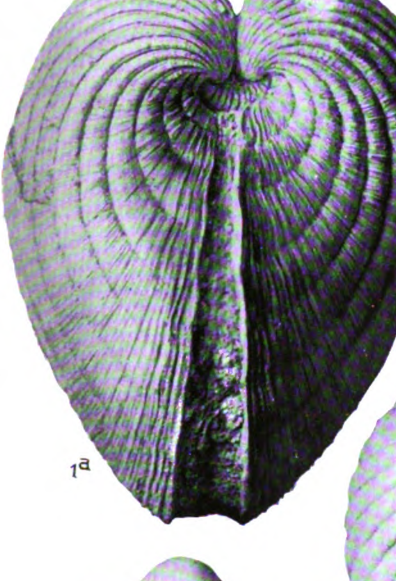
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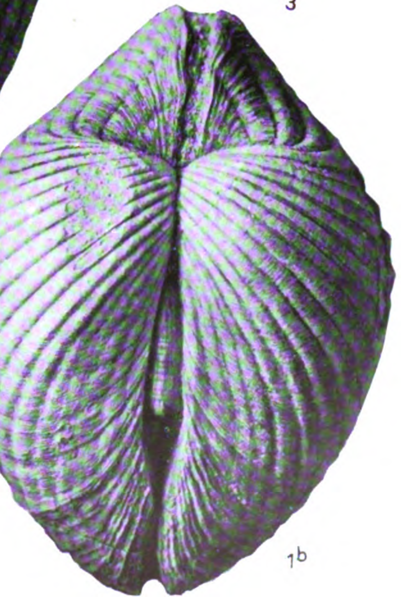
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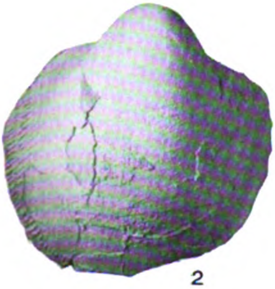
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EOCENE PELECYPODA.

PLATE XXVI.

EOCENE PELECYPODA AND GASTEROPODA.

(All figures natural size unless otherwise noted.)

FIG. 1. *Pecten* (*Chlamys*) *calkinsi* Arnold. Univ. California. An imperfect left valve; altitude 45 mm. Eocene, Sisar Creek, Ventura County.

FIG. 2. Same species as fig. 1. Univ. California. Imperfect right valve; altitude 29 mm. Same locality as fig. 1.

FIG. 3. *Pecten* (*Propeamusium*) *interradiatus* Gabb. Left valve; altitude 25 mm. Pal. Cal., vol. 2, pl. 33, fig. 98. Eocene shales at New Idria, San Benito County, and in Silver Thread district, Ventura County.

FIG. 3*a*. Same specimen as fig. 3. Interior of left valve. Pal. Cal., vol. 2, pl. 33, fig. 98.

FIG. 3*b*. Same species as fig. 3. Outline of ears of right valve. Pal. Cal., vol. 2, pl. 33, fig. 98*a*.

FIG. 4. *Glycymeris veatchii* Gabb var. *major* Stanton. U.S.N.M. 165003. Imperfect left valve; longitude 30 mm. Eocene, Rock Creek, Los Angeles County. Found in the lower Eocene (Martinez formation) in California.

FIG. 5. *Cardium brewerii* Gabb. Right valve; longitude 51 mm. Pal. Cal., vol. 2, pl. 24, fig. 155. Common in the Eocene (Tejon formation and equivalents).

FIG. 6. *Teredo* sp. U.S.N.M. 164972. Type. Imperfect section of tube, lateral view; diameter 11 mm. Eocene, Sisar Creek, Ventura County.

FIG. 6*a*. Same species as fig. 6. U.S.N.M. 164972. Cotype. Cross section of a crushed specimen; maximum diameter 15 mm. Same locality as fig. 6.

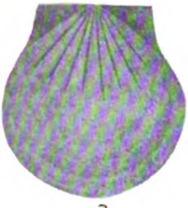
FIG. 7. *Fusus remondii* Gabb. Front view; altitude 41 mm. Pal. Cal., vol. 1, pl. 18, fig. 36. Common in Eocene (Tejon formation and equivalents) on west coast.

FIG. 7*a*. Same specimen as fig. 7. Magnified view of surface.

FIG. 8. *Amauropsis alveatus* Conrad. U.S.N.M. 165000. Front view of partially decorticated specimen; altitude 32 mm. Eocene, Rose Canyon, San Diego County. A characteristic Eocene gasteropod.

FIG. 9. *Morio* (*Sconsia*) *tuberculatus* Gabb. U.S.N.M. 164999. Front view of an imperfect and decorticated specimen; altitude 27 mm. Eocene, Rose Canyon, San Diego County. Perfect specimens have an anteriorly plicate plate over the inner lip; outer lip crenulate; revolving lines on surface.

FIG. 10. *Cylichna costata* Gabb. U.S.N.M. 165001. Front view of slightly imperfect specimen; altitude 18 mm., twice natural size. Eocene, Rose Canyon, San Diego County. Common in the Eocene (Martinez and Tejon formations and equivalents).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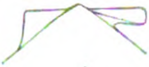
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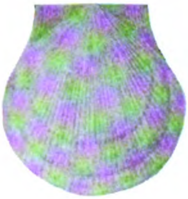
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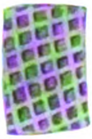
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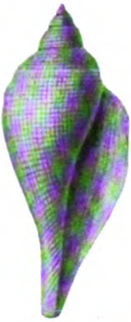
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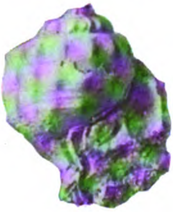
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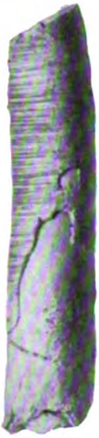
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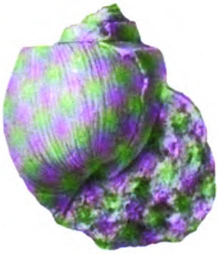
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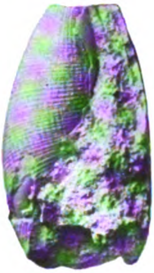
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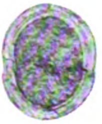
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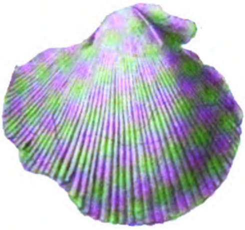
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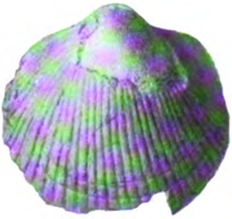
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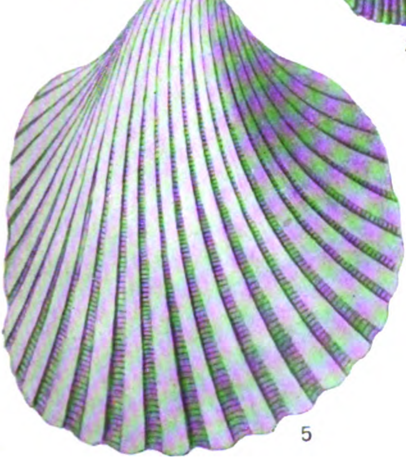
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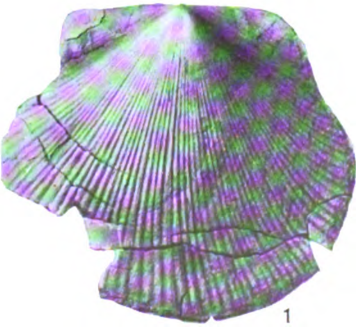
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EOCENE PELECYPODA AND GASTEROPODA.

PLATE XXVII.

MIOCENE PELECYPODA AND GASTEROPODA.

FIG. 1. *Pecten (Lyropecten) bowersi* Arnold. Univ. California. Type. Right valve; altitude 150 mm.; about two-thirds natural size. Lower Miocene, Santa Inez Mountains, Santa Barbara County. Also abundant at same horizon in Santa Monica Mountains and elsewhere. Left valve of this species more convex than right; otherwise very similar.

FIG. 2. *Ostrea titan* Conrad. U.S.N.M. 164987. Side view of both valves; altitude of large valve 131 mm.; two-thirds natural size. Lower Miocene, 3 miles south of Calabasas, Los Angeles County. This species is found in both the upper and lower Miocene, and often grows to a length of 20 inches (500 mm.) (See Pl. XXXII, fig. 2.)

FIG. 3. *Purpura edmondi* Arnold. U.S.N.M. 164983. Type. Aperture view; altitude 19 mm.; about 1⅓ times natural size. Lower Miocene, 3 miles south of Calabasas, Los Angeles County.

FIG. 3*a*. Reverse view of same specimen as fig. 3; same enlargement.

FIG. 4. *Chlorostoma* (*Omphalius*) *dalli* Arnold. U.S.N.M. 164984. Type. Aperture view; latitude 12.5 mm.; 1⅓ times natural size. Lower Miocene, 3 miles south of Calabasas, Los Angeles County. A common species in this horizon.

FIG. 4*a*. Top view of same specimen as fig. 4.

FIG. 4*b*. Base view of same specimen as fig. 4.

FIG. 5. *Chlorostoma* (*Omphalius*) *dalli* var. *inornatus* Arnold. U.S.N.M. 164986. Type. Top view; latitude 13.5 mm.; 1⅓ times natural size. Same locality as fig. 4.

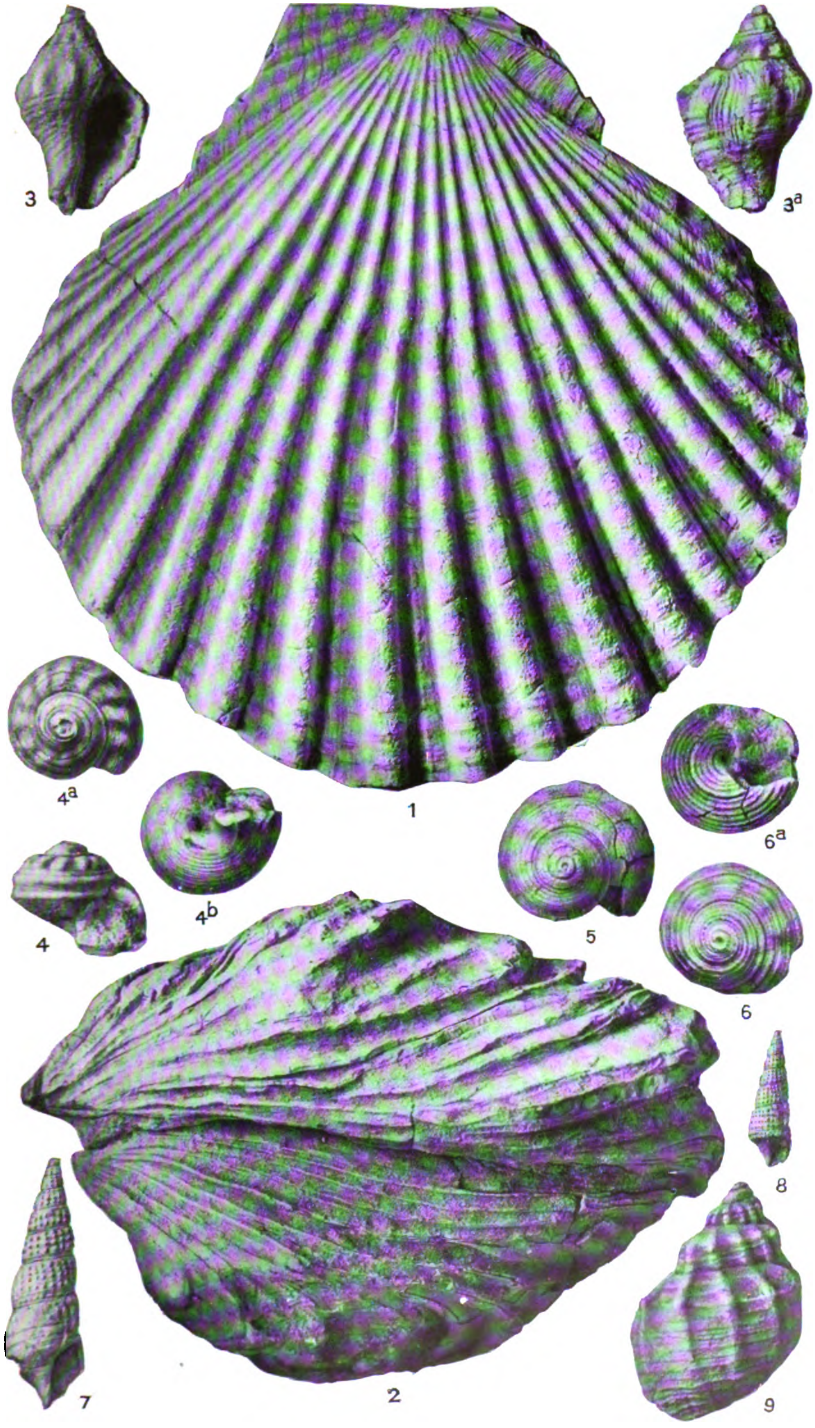
FIG. 6. *Chlorostoma* (*Omphalius*) *dalli* var. *subnodosus* Arnold. U.S.N.M. 164985. Type. Top view; latitude 13 mm.; 1⅓ times natural size. Same locality as Fig. 4.

FIG. 6*a*. Base view of same specimen as fig. 6.

FIG. 7. *Cerithium topangensis* Arnold. U.S.N.M. 164976. Type. Aperture view of imperfect specimen; longitude 23 mm.; 1½ times natural size. Lower Miocene, 3 miles south of Calabasas, at head of Topanga Canyon, Los Angeles County. A common species at the type locality.

FIG. 8. *Cerithium topangensis* Arnold. U.S.N.M. 164976. Cotype. Aperture view of imperfect specimen; longitude 13 mm.; 1⅓ times natural size. Same locality as fig. 7.

FIG. 9. *Cancellaria* cf. *condoni* Anderson. U.S.N.M. 164981. Back view of imperfect specimen; altitude 21 mm.; 1⅓ times natural size. Lower Miocene. 3 miles south of Calabasas, Los Angeles County. This species appears to range from the San Joaquin Valley to the Santa Monica Mountains in the lower Miocene.



MIOCENE PELECYPODA AND GASTEROPODA.

PLATE XXVIII.

MIOCENE PELECYPODA AND GASTEROPODA.

FIG. 1. *Pecten* (*Lyropecten*) *magnolia* Conrad. Univ. California. Imperfect right valve; altitude 14.5 mm.; about two-thirds natural size. Lower Miocene, Vaqueros formation, Ojai Valley, Ventura County. Characteristic of the lower Miocene throughout central and southern California. The left valve has narrow, more rounded ribs.

FIG. 2. *Pecten* (*Lyropecten*) *estrellanus* Conrad. U.S.N.M. 164851. Left valve; altitude 97 mm.; about two-thirds natural size. Upper Miocene, Wildhorse Canyon, Monterey County. This species is usually abundant in both the lower and upper Miocene faunas of central and portions of southern California. Ribs of right valve broader and anterior ear notched; otherwise similar to left.

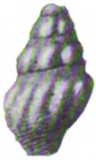
FIG. 3. *Drillia* sp. U.S.N.M. 164977. Type. Back view; longitude 13.5 mm.; about 1⅓ times natural size. Lower Miocene, head of Topanga Canyon, 3 miles south of Calabasas, Los Angeles County.

FIG. 4. *Macron merriami* Arnold. U.S.N.M. 164982. Type. Aperture view; longitude 23 mm.; about 1⅓ times natural size. Lower Miocene, same locality as fig. 3. This species appears to range over central and southern California in the lower Miocene.

FIG. 4*a*. Back view of same specimen as fig. 4.

FIG. 5. *Sigaretus perrini* Arnold. U.S.N.M. 164979. Type. Aperture view of partially decorticated and imperfect specimen; altitude 18.5 mm.; about 1⅓ times natural size. Lower Miocene, same locality as fig. 3.

FIG. 6. *Turbo topangensis* Arnold. U.S.N.M. 164980. Type. Aperture view; altitude 18.5 mm.; about 1⅓ times natural size. Lower Miocene, same locality as fig. 3.



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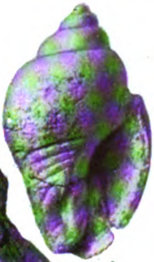

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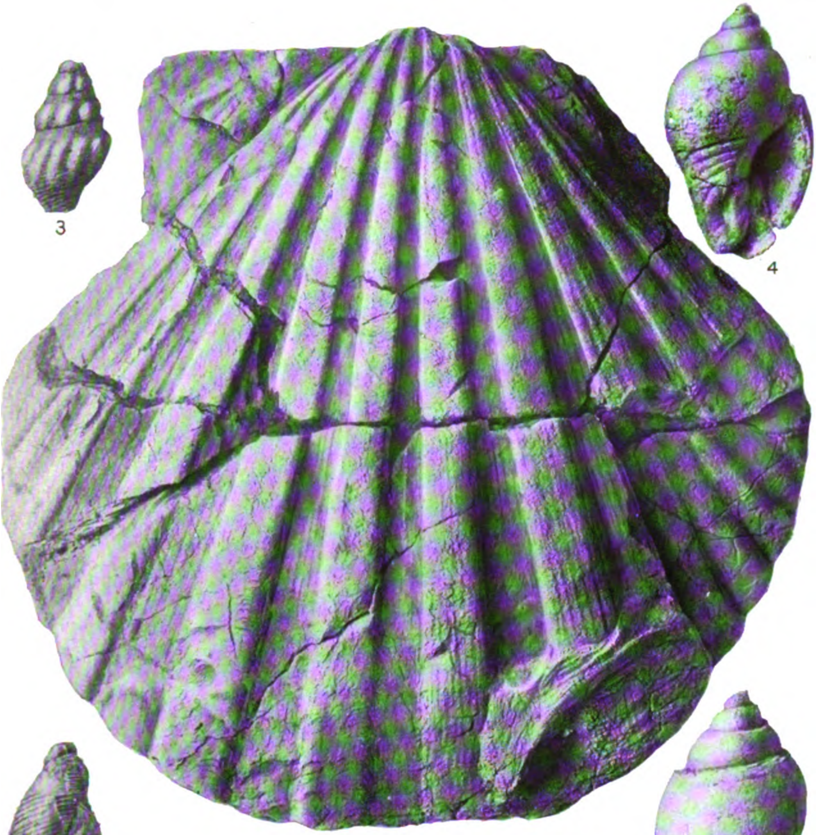

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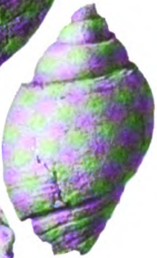

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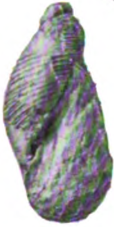

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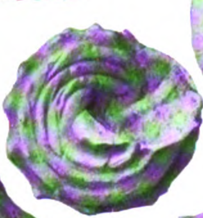

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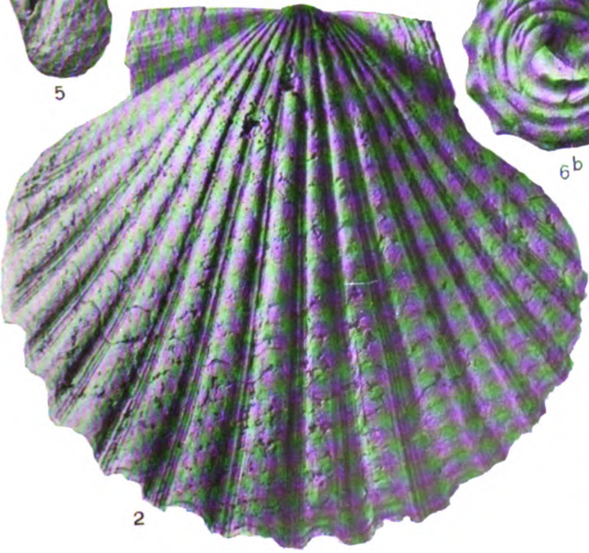

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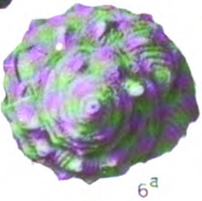

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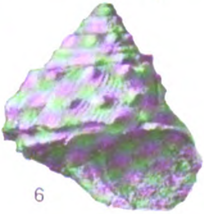

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MIOCENE PELECYPODA AND GASTEROPODA.

PLATE XXIX.

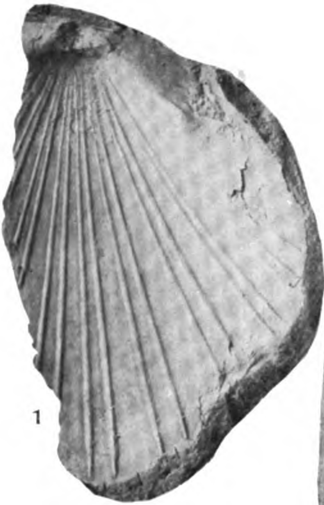
MIOCENE ECHINOIDEA AND PELECYPODA.

FIG. 1. *Pecten* (*Amusium*) *lompocensis* Arnold. U.S.N.M. 164852. Cotype. Interior view, showing internal liræ; altitude 90 mm.; about two-thirds natural size. Lower Miocene, Ojai Valley, Ventura County. This form, so far as known, is confined to the lower Miocene of Santa Barbara and Ventura counties.

FIG. 2. *Ostrea eldridgei* Arnold. U.S.N.M. 164986. Type. View of exterior of larger valve; altitude 14.7 mm.; two-thirds natural size. Lower Miocene, supposed equivalent of Vaqueros formation, Elkins ranch, east of Grimes Canyon, south of Fillmore, Ventura County.

FIG. 2*a*. Lateral view of same specimen as fig. 2.

FIG. 3. *Scutella fairbanksi* Merriam. U.S.N.M. 164963. View of top, showing details; maximum diameter 36 mm.; 1⅓ times natural size. Lower Miocene, supposed equivalent of Vaqueros formation, near Torrey Canyon wells, southwest of Piru, Ventura County; abundant. This species is also found near the base of the Vaqueros formation in the Sespe district. Supposed to be characteristic of the lower Miocene.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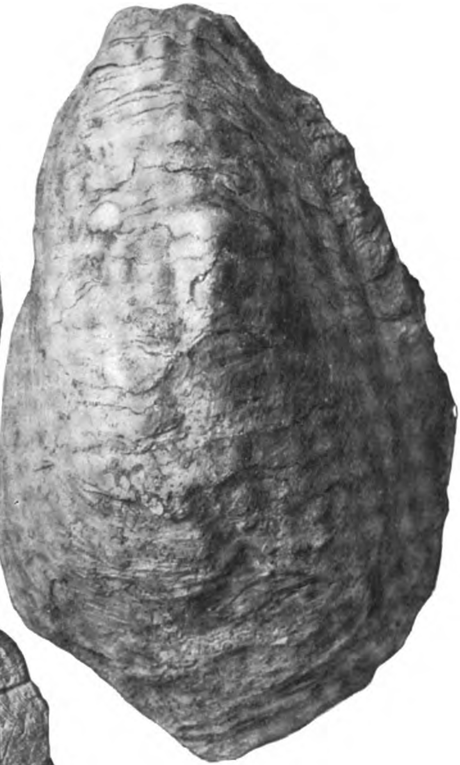
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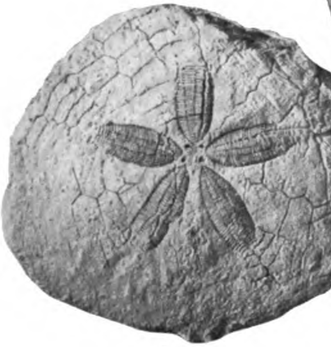
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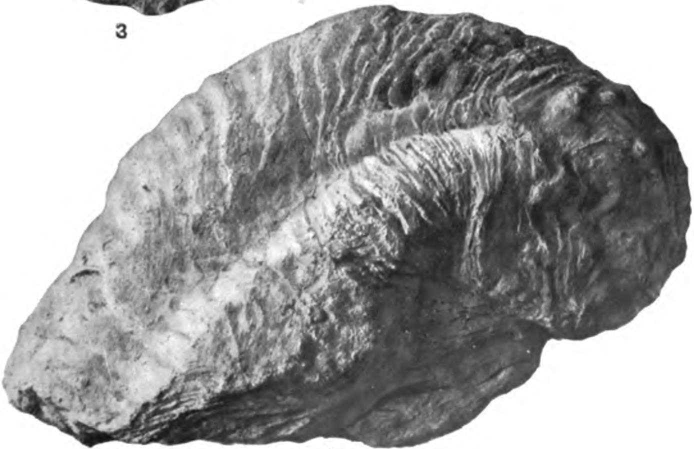
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MIOCENE ECHINOIDEA AND PELECYPODA.

PLATE XXX.

Miocene Echinoidea and Pelecypoda and Gasteropoda.

(All figures natural size.)

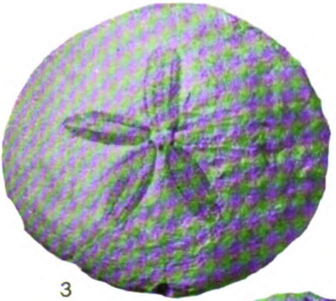
Fig. 1. *Venus (Chione) temblorensis* Anderson. U.S.N.M. 164989. Exterior of imperfect right valve; longitude 80 mm. Lower Miocene, head of Topanga Canyon, 3 miles south of Calabasas, Los Angeles County. Usually abundant in the lower Miocene; a nearly related, possibly identical form found in the upper Miocene.

Fig. 1*a*. Top view of same specimen as fig. 1.

Fig. 2. *Mytilus mathewsonii* Gabb var. *expansus* Arnold. U.S.N.M. 164968. Type. Right valve; altitude 10.5 mm. Lower Miocene, supposed equivalent of the Vaqueros formation, near Torrey Canyon wells, southwest of Piru, Ventura County. This species is usually found in the faunas of the lower Miocene through central and southern California.

Fig. 3. *Scutella fairbanksi* Merriam. U.S.N.M. 164963. Same locality as fig. 2, but possibly at a somewhat lower horizon.

Fig. 4. *Ocinebra topangensis* Arnold. U.S.N.M. 164995. Type. Back view; altitude 59 mm. Lower Miocene, Topanga Canyon, 3 miles south of Calabasas, Los Angeles County. So far known only from this horizon.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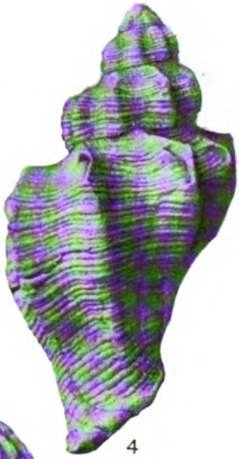
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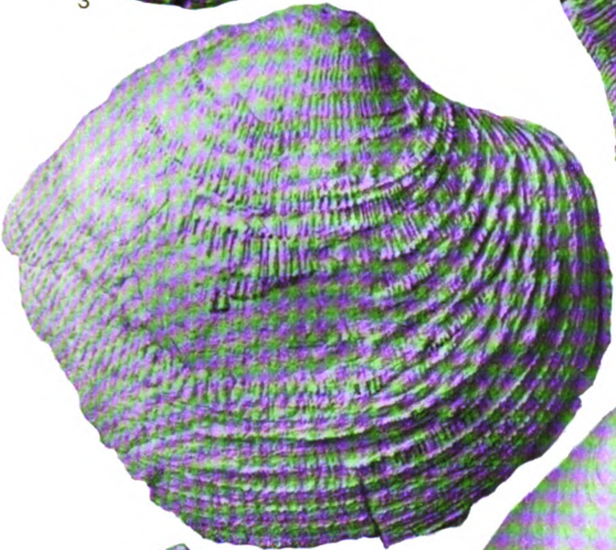
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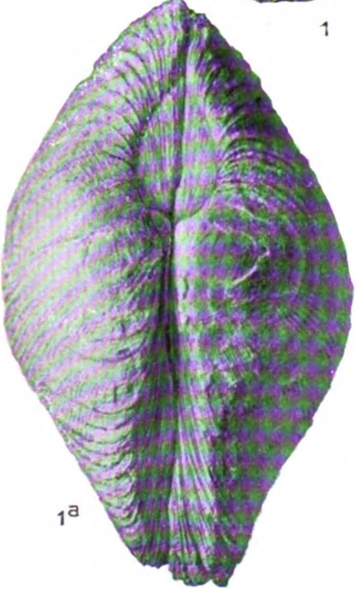
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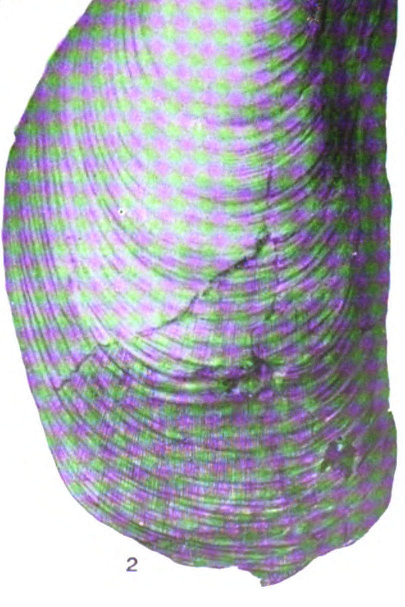
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MIOCENE ECHINOIDEA, PELECYPODA, AND GASTEROPODA.

PLATE XXXI.

MIOCENE PELECYPODA AND GASTEROPODA.

(All figures natural size.)

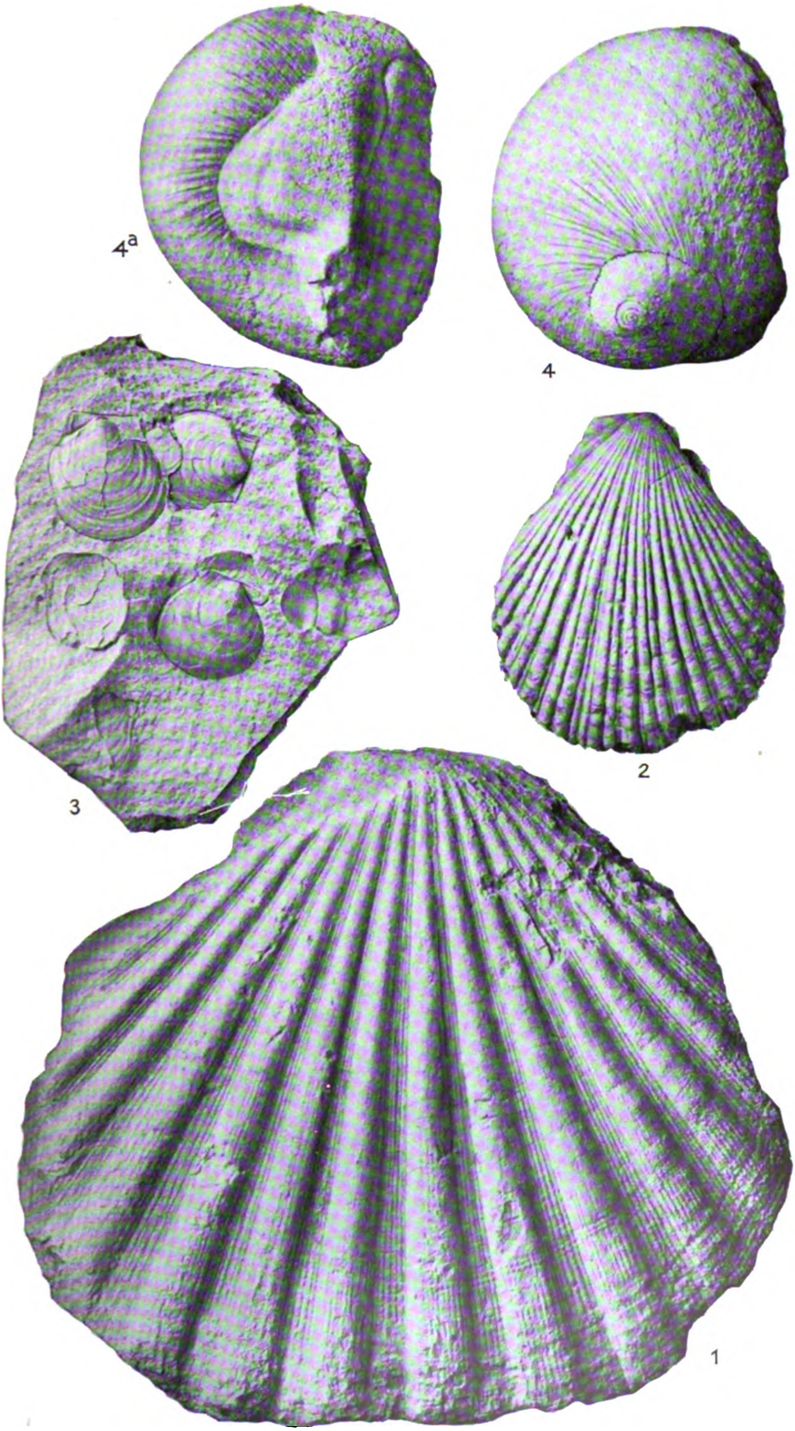
FIG. 1. *Pecten* (*Lyropecten*) *crassicardo* Conrad. U.S.N.M. 164967. Exterior of valve, showing characteristic sculpture; altitude 90 mm. Lower Miocene, Ojai Valley, Ventura County. This species ranges through the lower and upper Miocene, being commoner in the former in southern California, in the latter in central California. It is sometimes more convex than the figured specimen, and often shows concentric undulations of the disk.

FIG. 2. *Pecten* (*Chlamys*) ***sespeensis*** var. ***hydei*** Arnold. Collection of Delos Arnold. Type. Right valve, ear missing; altitude 46 mm. Lower Miocene, Lynchs Mountain, San Luis Obispo County. Found also in the Vaqueros formation, Little Sespe Creek, and, with *Mytilus mathewsonii* Gabb, in supposed equivalents of the Vaqueros formation near the Torrey Canyon wells, Ventura County.

FIG. 3. *Pecten* (*Pseudamusium*) *peckhami* Gabb. U.S.N.M. 164839. Right and left valves in matrix; altitude of largest 17 mm. Monterey shale (middle Miocene), southeast of Pinole, Contra Costa County. The type of this species came from the Ojai Valley, Ventura County. It is the commonest form in the shales of the middle Miocene (Monterey, Modelo, and equivalent formations) and is also known from the Oligocene in the Santa Cruz Mountains.

FIG. 4. *Neverita callosa* Gabb. U.S.N.M. 164992. View from above, specimen slightly tilted; maximum latitude 44 mm. Lower Miocene, head of Topanga Canyon, 3 miles south of Calabasas, Los Angeles County. Ranges through the Miocene. Common in the lower Miocene of southern San Joaquin Valley and the Santa Monica Mountains.

FIG. 4*a*. Same specimen as fig. 4. View of base and aperture, showing characteristic shape of callous.



MIOCENE PELECYPODA AND GASTEROPODA.

PLATE XXXII.

MIOCENE PELECYPODA, GASTEROPODA, AND CRUSTACEA.

(All figures natural size.)

FIG. 1. *Pecten* (*Hinnites*) *giganteus* Gray. U.S.N.M. 164965. Exterior of right valve; altitude 90 mm. Lower Miocene, supposed equivalent of Vaqueros formation, gulch east of Wiley Canyon, southwest of Piru, Ventura County. A very variable species ranging from the lower Miocene to the Recent fauna.

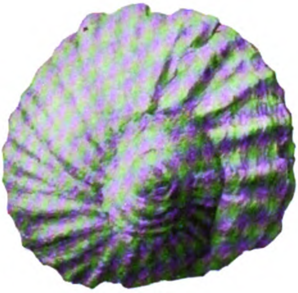
FIG. 2. *Ostrea titan* Conrad. U.S.N.M. 164987. View of exterior of larger valve; altitude 131 mm. Lower Miocene, 3 miles south of Calabasas, Los Angeles County. A common form in the upper and lower Miocene; often grows to a length of 20 inches (500 mm.) or more. (See Pl. XXVII, fig. 2.)

FIG. 3. *Trochita costellata* Conrad. U.S.N.M. 164994. View from above; maximum diameter 38 mm. Same locality as fig. 2. Common in the Miocene.

FIG. 4. *Phacoides richthofeni* Gabb. U.S.N.M. 164978. Right valve; altitude 17.5 mm. Same locality as fig. 2.

FIG. 5. *Balanus concavus* Bronn. U.S.N.M. 164971. Type. Lateral view; maximum latitude 26 mm. Lower Miocene or upper Oligocene, Little Sespe Creek, Ventura County. A very common species in this horizon.

FIG. 5*a*. Same species as fig. 5. Top view.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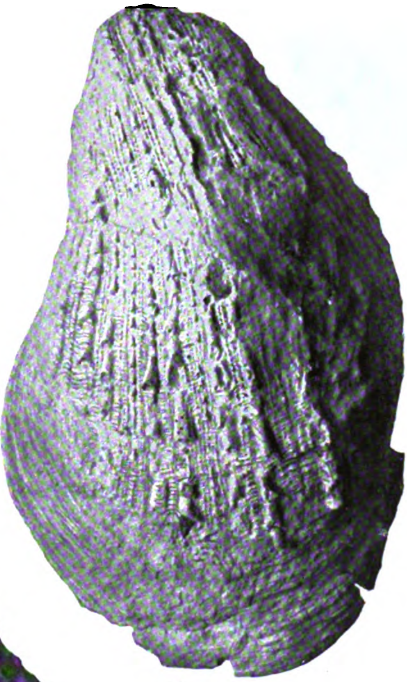
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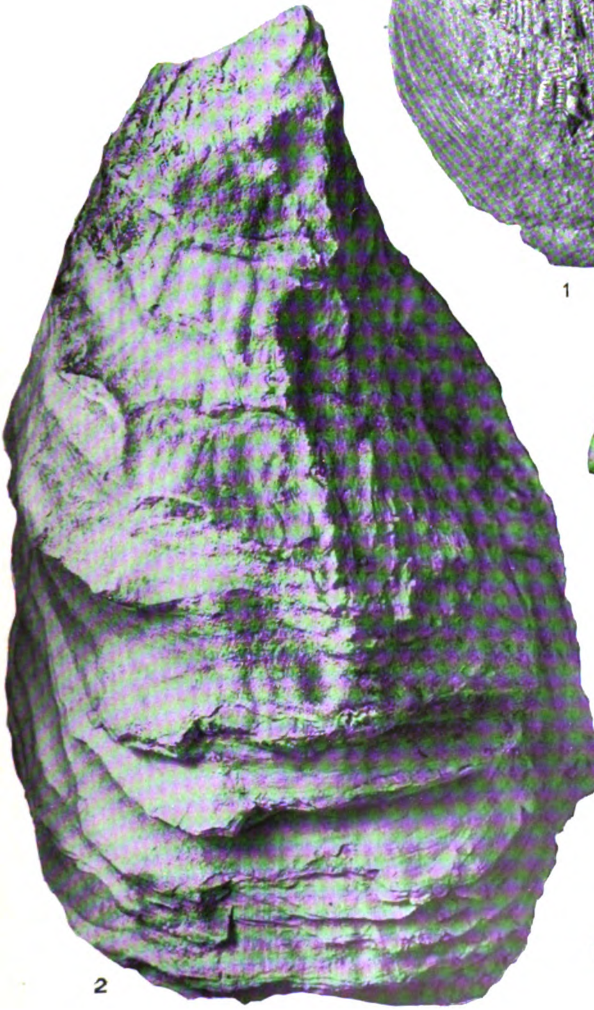
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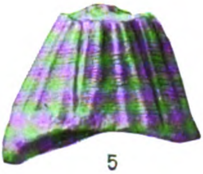
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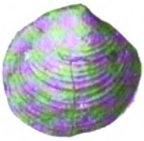
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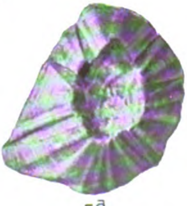
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MIOCENE PELECYPODA, GASTEROPODA, AND CRUSTACEA.

PLATE XXXIII.

MIOCENE PELECYPODA AND GASTEROPODA.

(All figures natural size.)

FIG. 1. *Pecten (Chlamys) sespeensis* Arnold. California State Mining Bureau. Cotype Portion of mold of interior of right valve; altitude 50 mm. Lower Miocene, Vaqueros formation, Sespe Canyon, Ventura County. A common species at the type locality; also found elsewhere in central and southern California in the lower Miocene.

FIG. 1*a*. Mold of interior of left valve of same specimen as fig. 1.

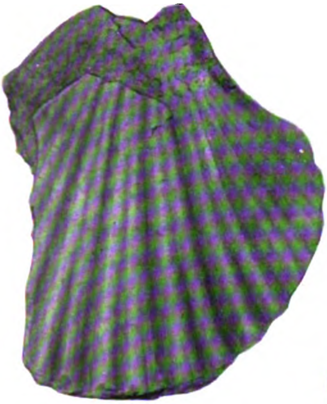
FIG. 2. *Pecten (Chlamys) sespeensis* Arnold. California State Mining Bureau. Plastotype. Cast of exterior of slightly imperfect left valve (young); altitude. 18 mm. Same locality as fig. 1.

FIG. 3. *Pecten (Lyropecten) vaughani* Arnold. Collection of Delos Arnold. Type. Right valve; altitude 37 mm. Lower Miocene, supposed equivalent of Vaqueros formation, Ojai Valley, Ventura County.

FIG. 3*a*. Same specimen as fig. 3. Left valve.

FIG. 4. *Dosinia ponderosa* Gray. U.S.N.M. 164988. Imperfect right valve; altitude 80 mm. Lower Miocene, 3 miles south of Calabasas, Los Angeles County. A common species from the lower Miocene to the Recent southern fauna of the west coast.

FIG. 5. *Pleurotoma (Dolichotoma) keepi* Arnold. U.S.N.M. 164993. Type. Back view of imperfect specimen. Same locality as fig. 4. Found also in this horizon at several localities in southern San Joaquin Valley.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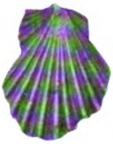
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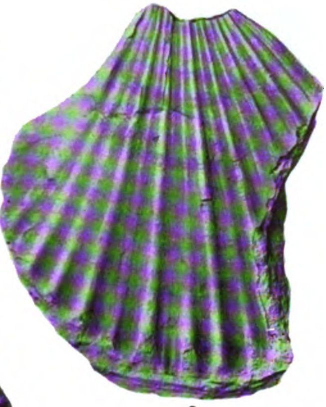
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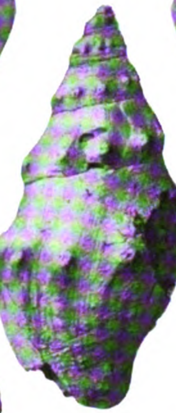
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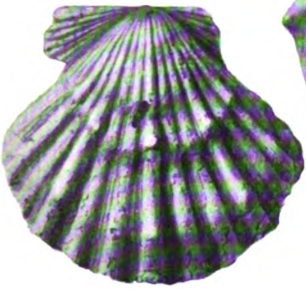
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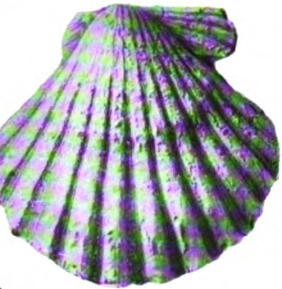
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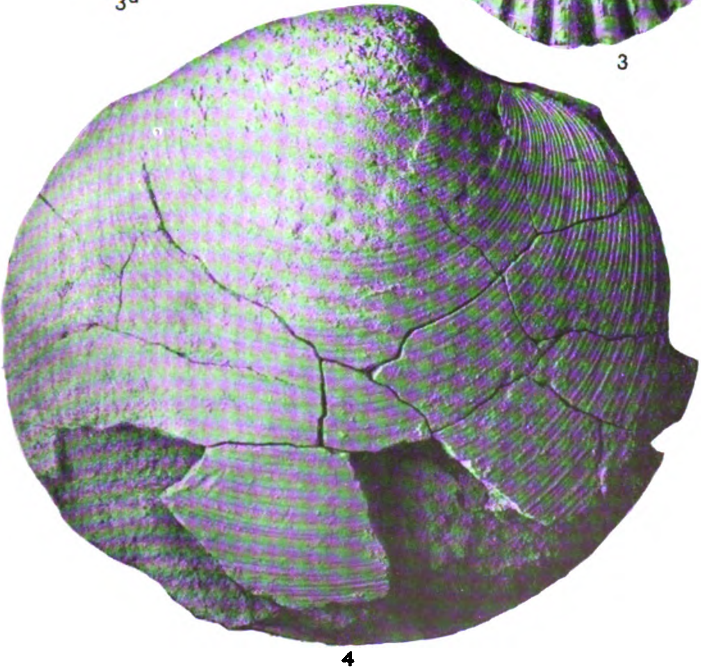
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MIOCENE PELECYPODA AND GASTEROPODA.

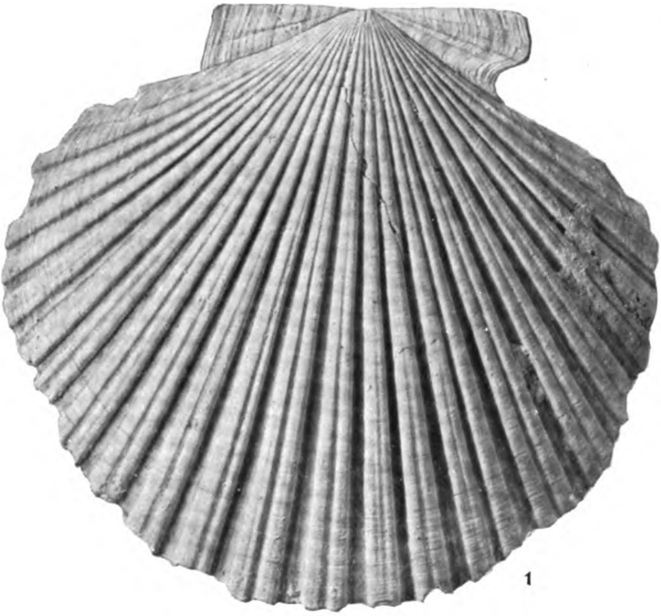
PLATE XXXIV.

PLIOCENE PECTENS.

(All figures about two-thirds natural size.)

FIG. 1. *Pecten* (*Patinopecten*) *healeyi* Arnold. U.S.N.M. 148012. Type. Exterior of right valve; altitude 121 mm. San Diego formation (Pliocene), San Diego County. A characteristic form in the lower Pliocene from San Mateo County to the Mexican line. Left valve with narrow rounded ribs and intercalaries; disk also less convex.

FIG. 2. *Pecten* (*Lyropecten*) *ashleyi* Arnold. Univ. California. Type. Exterior of right valve; altitude 155 mm. Pliocene, Cerros Island, off Lower California. Also characteristic of the lower Pliocene, but so far known only as far north as Santa Barbara County. The left valve has slightly narrower ribs and no byssal notch in the anterior ear.



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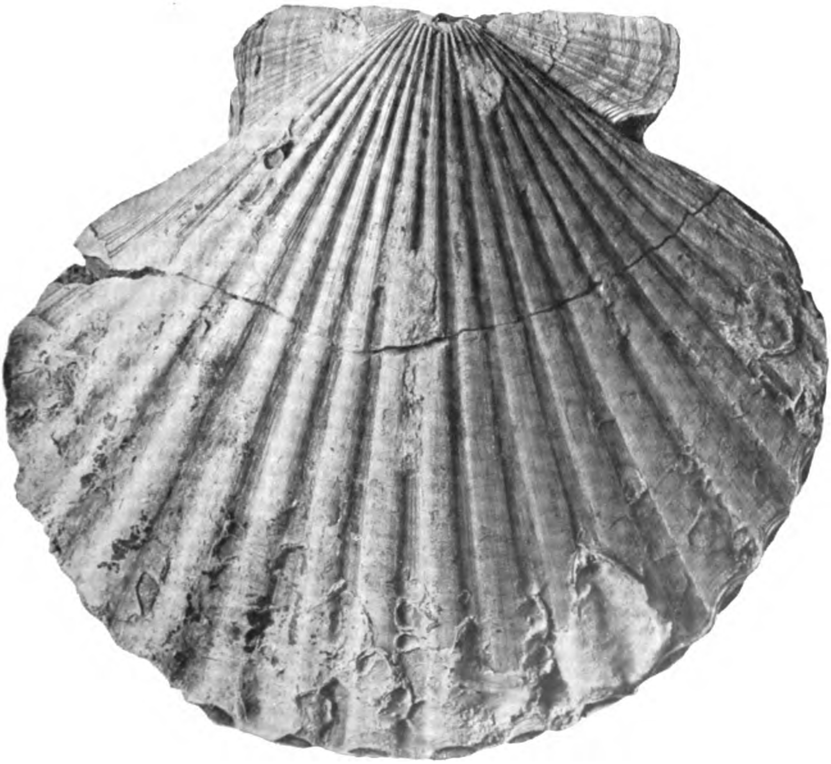


PLIOCENE PECTENS

PLATE XXXV.

PLIOCENE PECTENS.

(Unless otherwise stated all figures are about two-thirds natural size.)

FIG. 1. *Pecten* (*Chlamys*) *wattsi* Arnold. California Acad. Sci. Type. Exterior of slightly imperfect left valve; altitude 66 mm. Lower Pliocene, Kreyenhagen's ranch, Fresno County. Also found in the lower Pliocene of southern California. Right valve with broader, flatter ribs.

FIG. 2. *Pecten* (*Pecten*) *stearnsii* Dall. U.S.N.M. 148008. Exterior of left valve; altitude 87 mm. San Diego formation (Pliocene), Pacific Beach, San Diego County. Not rare in the Pliocene. (See Pl. XXXVI, fig. 4, for right valve.)

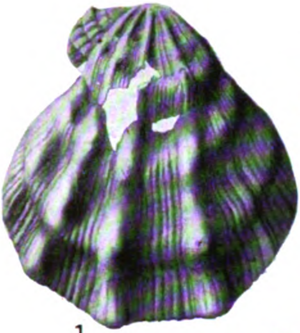
FIG. 3. *Pecten* (*Pecten*) *bellus* Conrad. Acad. Nat. Sci. Phila. 960. Exterior of right valve; altitude 80 mm.; about five-sixths natural size. Pliocene, Santa Barbara. Also found in Pliocene of Ventura, Santa Barbara, and adjacent counties. Left valve slightly concave, with narrower ribs than right; otherwise similar.

FIG. 4. *Pecten* (*Plagioctenium*) *circularis* Sowerby. U.S.N.M. 61246. Right valve; longitude 26 mm.; nearly natural size. Pleistocene, Ventura County. May also extend down into the Pliocene.

FIG. 5. *Pecten* (*Pecten*) *vogdesi* Arnold. California Acad. Sci. Cotype. Exterior of slightly imperfect left valve; altitude 74 mm. Pleistocene, Ventura County. Also occurs in supposed Pliocene near San Diego. Right valve very convex, with broad rounded ribs.

FIG. 6. *Pecten* (*Plagioctenium*) *cerrosensis* Gabb. Univ. California. Exterior of left valve (anterior ear slight broken); altitude 106 mm. Pliocene, Cerros Island, off Lower California. Also found in the Pliocene near Camulos, Newhall, and San Diego.

FIG. 7. *Pecten* (*Pecten*) *auburyi* Arnold. California State Mining Bureau. Type. Exterior of imperfect right valve; altitude 46 mm. Pliocene, Puente Hills, Los Angeles County. Left valve slightly concave, with ribs narrower than in right.



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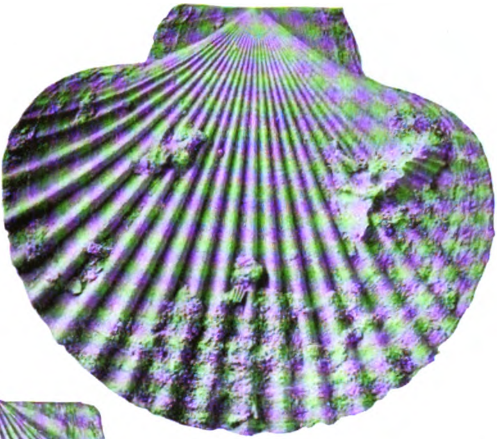

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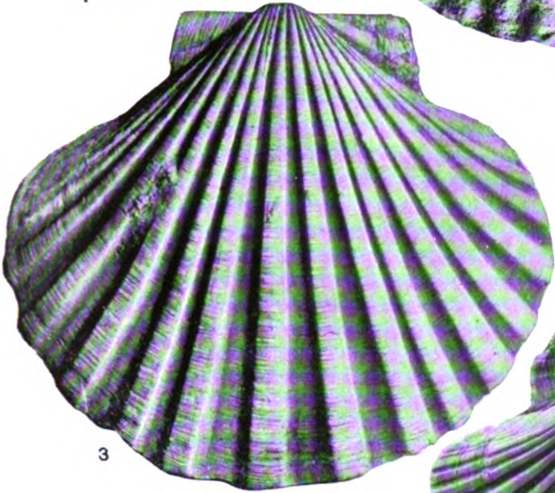

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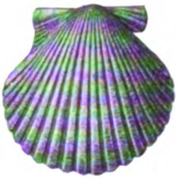

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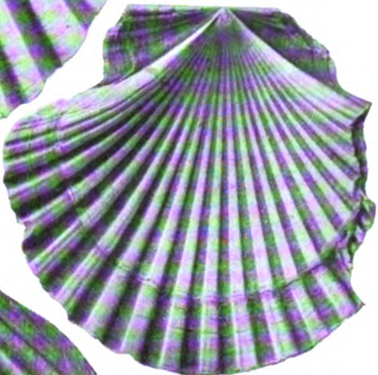

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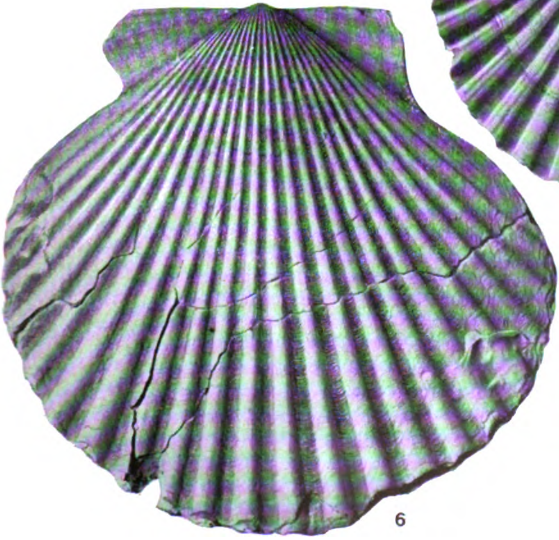

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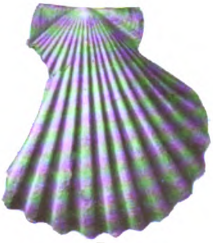

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PLIOCENE PECTENS.

PLATE XXXVI.

PLIOCENE PECTENS.

(All figures about two-thirds natural size.)

FIG. 1. *Pecten* (*Patinopecten*) *caurinus* Gould. Collection of Delos Arnold. Exterior of left valve; altitude 105 mm. Pliocene, Deadman Island, Los Angeles County. Specimens of this species measuring over 8 inches (200 mm.) have been found in the Pliocene of Ventura County. This form appears to be confined to the upper Pliocene and Pleistocene in southern California. Right valve more convex and with broader square ribs and plain concentric sculpture.

FIG. 2. *Pecten* (*Chlamys*) *latiauritus* Conrad. Collection of Delos Arnold. Exterior of right valve; altitude 25 mm. San Pedro formation (Pleistocene), San Pedro, Los Angeles County. Known also from the lower Pliocene at Los Angeles.

FIG. 3. *Pecten* (*Chlamys*) *latiauritus* Conrad. Collection of Delos Arnold. Exterior of left valve; altitude 27 mm. Same locality as fig. 2.

FIG. 4. *Pecten* (*Pecten*) *stearnsii* Dall. U.S.N.M. 148008. Exterior of right valve; altitude 87 mm. San Diego formation (Pliocene), Pacific Beach, San Diego County. (See Pl. XXXV, fig. 2, for left valve.)

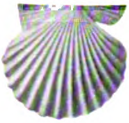
FIG. 5. *Pecten* (*Pseudamusium*) *pedroanus* Trask. U.S.N.M. 164840. Exterior of right valve and young left valve; altitude of former, 22 mm. Lower Pliocene, Third street tunnel, Los Angeles. Also found in beds of supposed Miocene age in the Puente Hills and San Pedro.

FIG. 6. *Pecten* (*Pseudamusium*) *pedroanus* Trask. U.S.N.M. 164840. Exterior of imperfect left valve; altitude 30 mm. Same locality as fig. 5.

FIG. 7. *Pecten* (*Chlamys*) *parmeleei* Dall. U.S.N.M. 154479. Type. Left valve; altitude 45 mm.; about five-sixths natural size. Pliocene, Pacific Beach, San Diego County. Also known in Pliocene of Puente Hills.

FIG. 8. *Pecten* (*Chlamys*) *opuntia* Dall. U.S.N.M. 107752. Type. Right valve; altitude 33 mm.; about four-fifths natural size. Pliocene, Pacific Beach, San Diego County. Also common in Pliocene at Santa Barbara and elsewhere in southern California.

FIG. 9. *Pecten* (*Pecten*) *merriami* Arnold. California State Mining Bureau. Type. Exterior of imperfect left valve; altitude 110 mm. Pliocene, Piru Creek, Ventura County. Characteristic of the lower Fernando horizon (lower Pliocene or upper Miocene) so far as known. Right valve convex, with broader squarer ribs.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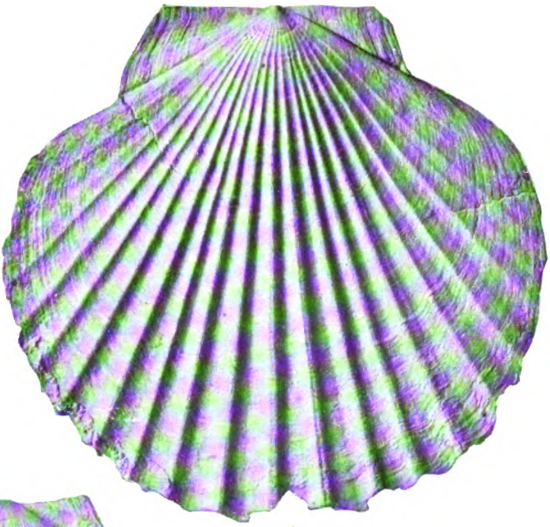
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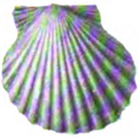
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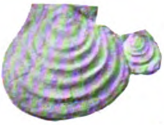
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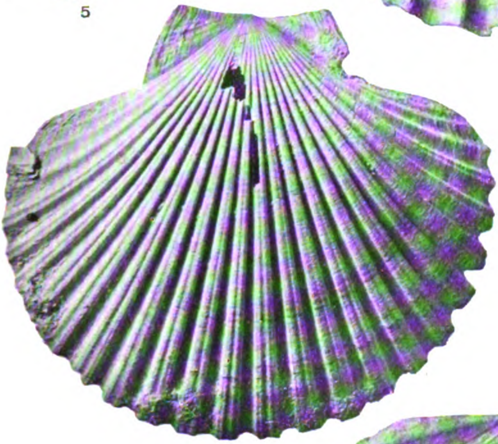
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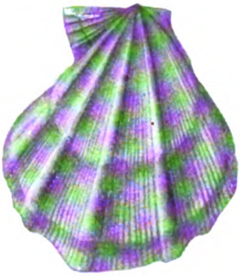
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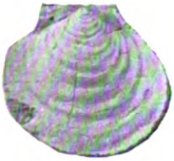
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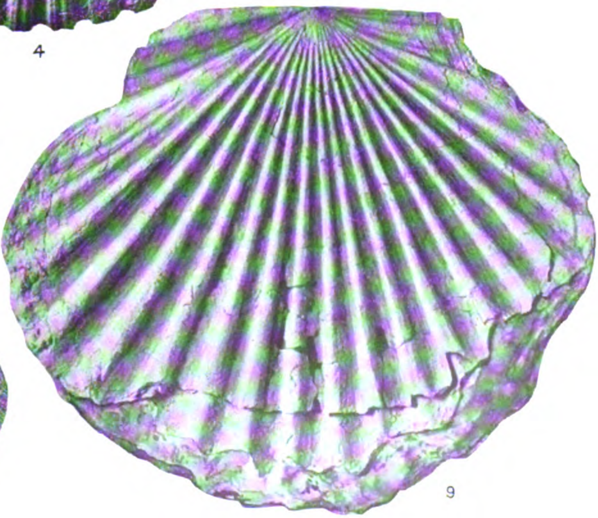
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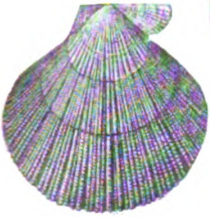
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PLIOCENE PECTENS.

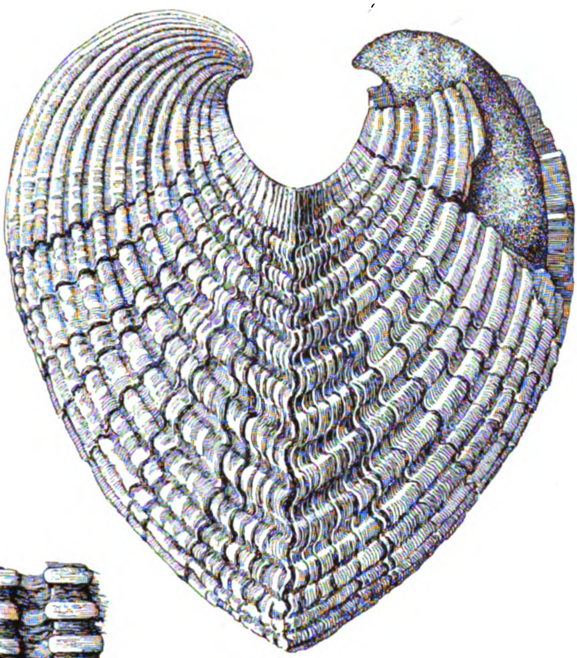
PLATE XXXVII.

PLIOCENE ARCAS.

FIG. 1. *Arca camuloensis* Osmont. California State Mining Bureau. Type. Right valve; altitude 89 mm. Fernando formation, lower Pliocene or upper Miocene, 1 mile north of Camulos, Ventura County. So far as known this species is characteristic of the lower horizon of the Fernando formation. Also reported from the Puente Hills.

FIG. 1*a*. End view of same specimen as fig. 1.

FIG. 1*b*. Portion of surface of same specimen as fig. 1, enlarged, showing nodose ribs.



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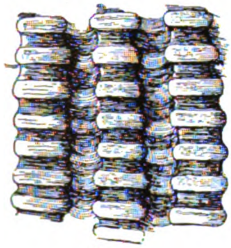

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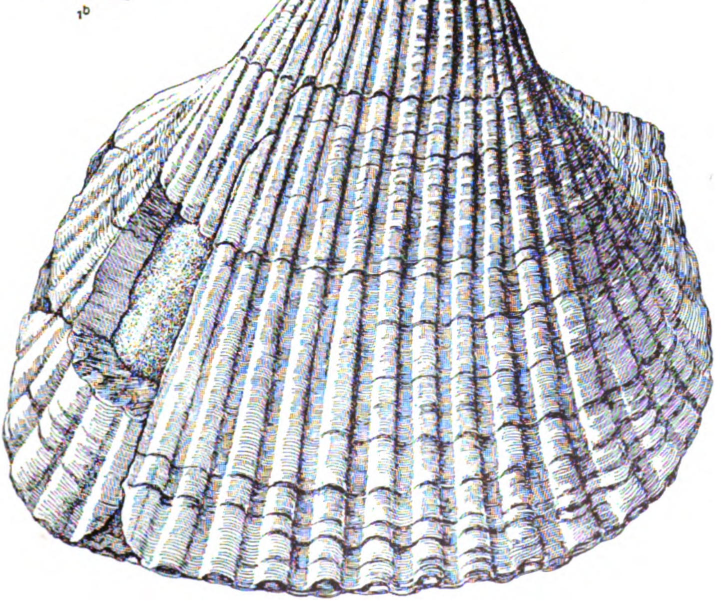

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PLIOCENE ARCAS.

PLATE XXXVIII.

PLIOCENE PELECYPODA AND GASTEROPODA.

(Unless otherwise stated all figures natural size.)

FIG. 1. *Arca multicostata* Sowerby. U.S.N.M. 12574. Right valve; longitude 101 mm. Recent, San Diego. Found in the lower Pliocene (Fernando formation) in the Puente Hills, Orange County, and in the vicinity of Los Angeles.

FIG. 2. *Cardium quadrigenarium* Conrad var. *fernandoensis* Arnold. U.S.N.M. 164947. Type. Imperfect left valve; longitude 58 mm. Lower Pliocene (Fernando formation), Elsmere Canyon, near Newhall, Los Angeles County. A common variety in the lower Pliocene. The typical form with 44 ribs and less obliquity is found in the Recent.

FIG. 2*a*. Same specimen as fig. 2. View of umbos from above.

FIG. 3. *Arca trilineata* Conrad. U.S.N.M. 164948. Right valve of medium-sized specimen; longitude 40 mm. Same locality as fig. 2. A common species in the Pliocene of California. Also appears to extend down as far as the middle Miocene (Monterey).

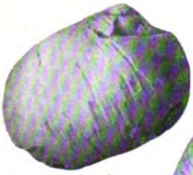
FIG. 3*a*. Same specimen as fig. 3. Umbos and hinge area viewed from above.

FIG. 4. *Arca trilineata* Conrad. Portion of an adult left valve, showing the more complex sculpture of the ribs in the later stages of growth; altitude 60 mm. Same locality as fig. 2.

FIG. 5. *Leda taphria* Dall. U.S.N.M. 164952. Right valve; longitude 36 mm.: twice natural size. Same locality as fig 2. This species is common from the Pliocene to the Recent fauna in the California province.

FIG. 5*a*. Same specimen as fig. 5. View of umbos from above.

FIG. 6. *Neverita recluziana* Petit. U.S.N.M. 164960. Back view; latitude 25 mm. Same locality as fig. 2. A common species from the Pliocene to the Recent fauna; also probably occurs in the Miocene.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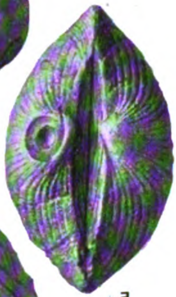
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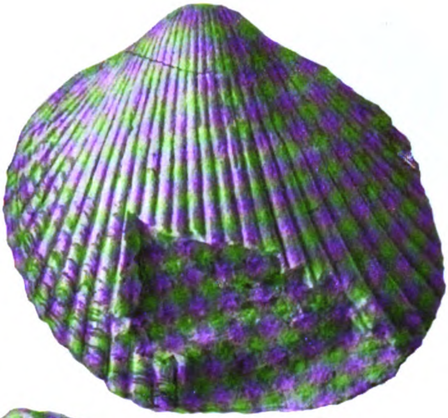
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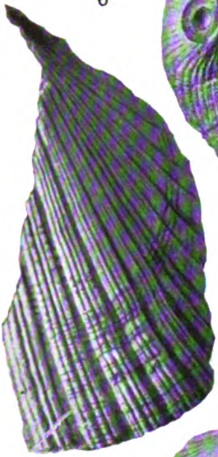
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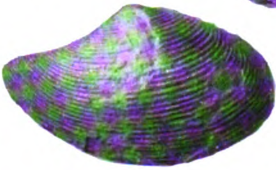
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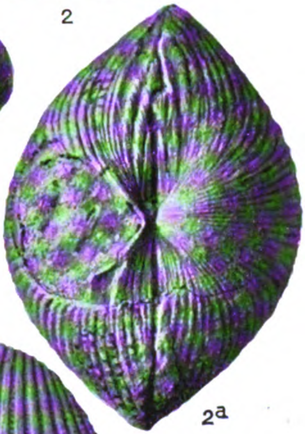
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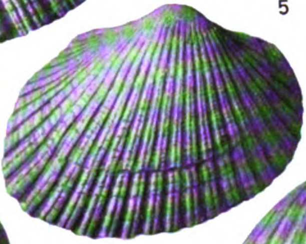
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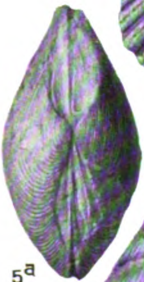
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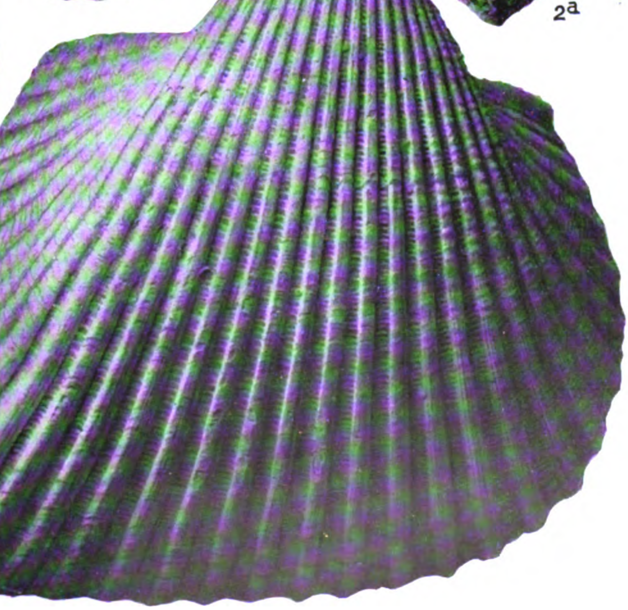


PLIOCENE PELECYPODA AND GASTEROPODA.

PLATE XXXIX.

PLIOCENE BRACHIOPODA AND PELECYPODA.

(All figures natural size.)

FIG. 1. *Ostrea veatchii* Gabb. U.S.N.M. 153827. Exterior of valve; altitude 90 mm. Lower Pliocene, San Diego. An abundant and characteristic species in many of the Pliocene localities from southern California to Cerros Island, off lower California.

FIG. 2. *Callista* (*Amiantis*) *callosa* Conrad. U.S.N.M. 164953. Imperfect left valve; altitude 50 mm. Lower Pliocene (Fernando formation), Elsmere Canyon, near Newhall, Los Angeles County. Base evenly rounded in perfect specimens. Common from Pliocene to Recent.

FIG. 3. *Callista subdiaphana* Carpenter. U.S.N.M. 164951. Imperfect right valve; longitude 41 mm. Same locality as fig. 2. Abundant in the Pliocene and also found in the Recent.

FIG. 4. *Terebratalia smithi* Arnold. U.S.N.M. 164977. Pedicle valve; longitude 42 mm. Pliocene, Temescal Canyon, 3 miles north of Santa Monica, Los Angeles County. Known only from the Pliocene. A somewhat variable species.

FIG. 4*a*. Same specimen as fig. 4. Brachial valve.

FIG. 5. *Terebratalia smithi* Arnold. U.S.N.M. 164977. Pedicle valve; longitude 29 mm. Same locality as fig. 4. More prominent ribbing than specimen shown in fig. 4.

FIG. 5*a*. Same specimen as fig. 5. Brachial valve.

FIG. 6. *Terebratalia occidentalis* Dall. U.S.N.M. 164996. Brachial valve; longitude 40 mm. Same locality as fig. 4. This species is most variable, as is evidenced by this and the following figures, which show a series collected at one locality. Found in the lower Pliocene (and possibly upper Miocene).

FIG. 7. Same species and locality as fig. 6. Pedicle valve; longitude 29 mm.

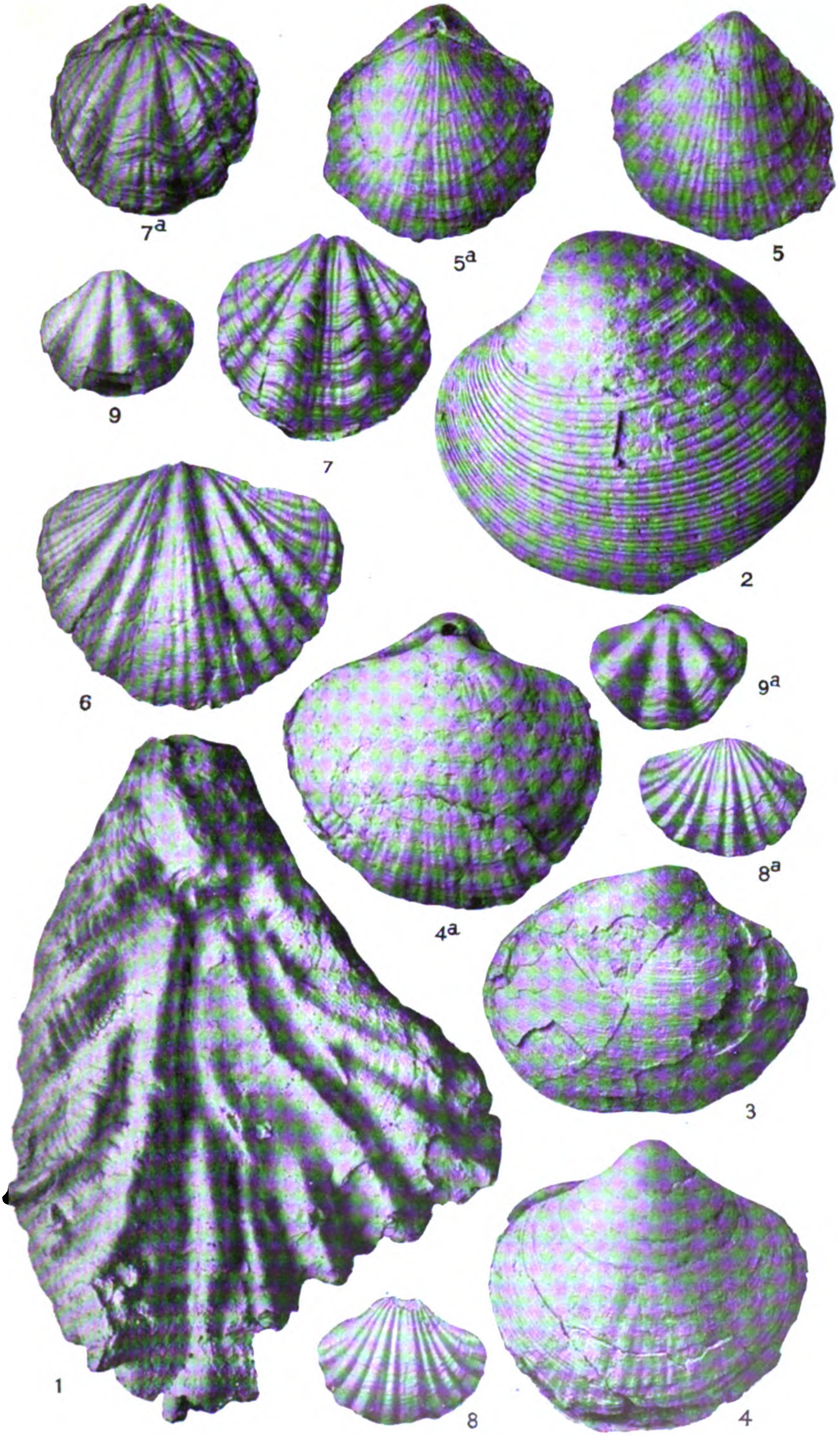
FIG. 7*a*. Same specimen as fig. 7. Brachial valve.

FIG. 8. Same species and locality as fig. 6. Pedicle valve; longitude 22 mm.

FIG. 8*a*. Same specimen as fig. 8. Brachial valve.

FIG. 9. Same species and locality as fig. 6. Pedicle valve of a less rugose variety; longitude 21 mm.

FIG. 9*a*. Same specimen as fig. 8. Brachial valve.



PLIOCENE BRACHIOPODA AND PELECYPODA.

PLATE XL.

PLIOCENE PELECYPODA AND GASTEROPODA.

(Unless otherwise stated, all figures are natural size.)

FIG. 1. *Mya truncata* Linné. U.S.N.M. 164950. Left valve; longitude 46 mm. Pliocene (Fernando formation), Elsmere Canyon, near Newhall, Los Angeles County. Found also in the Recent fauna of the Arctic regions.

FIG. 2. *Trochita filosa* Gabb. U.S.N.M. 164949. Slightly imperfect specimen viewed from above; maximum diameter 20 mm.; twice natural size. Same locality as fig. 1. Also found in the upper Miocene.

FIG. 2*a*. Same specimen as fig. 2. View from the side.

FIG. 3. *Fissuridea murina* Carpenter. U.S.N.M. 164945. Specimen viewed from above; longitude 14.5 mm.; twice natural size. Lower Pliocene, Third street tunnel, Los Angeles. Also found in the Pleistocene and Recent fauna of the coast.

FIG. 3*a*. Same specimen as fig. 3. View from the side.

FIG. 4. *Cancellaria fernandoensis* Arnold. U.S.N.M. 164956. Back view of imperfect specimen; altitude 17 mm.; twice natural size. Same locality as fig. 1. A similar or identical form was found in the Pliocene of the San Diego well.

FIG. 5. *Tritonium* sp. U.S.N.M. 164954. Back view of imperfect specimen; altitude 20 mm.; twice natural size. Same locality as fig. 1.

FIG. 6. *Pisania fortis* Carpenter var. *angulata* Arnold. U.S.N.M. 164959. Aperture view of imperfect young; altitude 30 mm. Same locality as fig. 1. A rather common species in the Pleistocene and Pliocene of central and southern California.

FIG. 7. *Pisania fortis* Carpenter var. *angulata* Arnold. U.S.N.M. 164958. Aperture view of imperfect adult; altitude 49 mm. Same locality as fig. 1.

FIG. 8. *Cypræa fernandoensis* Arnold. U.S.N.M. 164961. Type. View from back; longitude 40 mm. So far known only from same locality as fig. 1.

FIG. 8*a*. Same specimen as fig. 8. Aperture view.

FIG. 9. *Nassa hamlini* Arnold. U.S.N.M. 164946. Type. Aperture view of imperfect specimen; longitude 15 mm. Same locality as fig. 3.

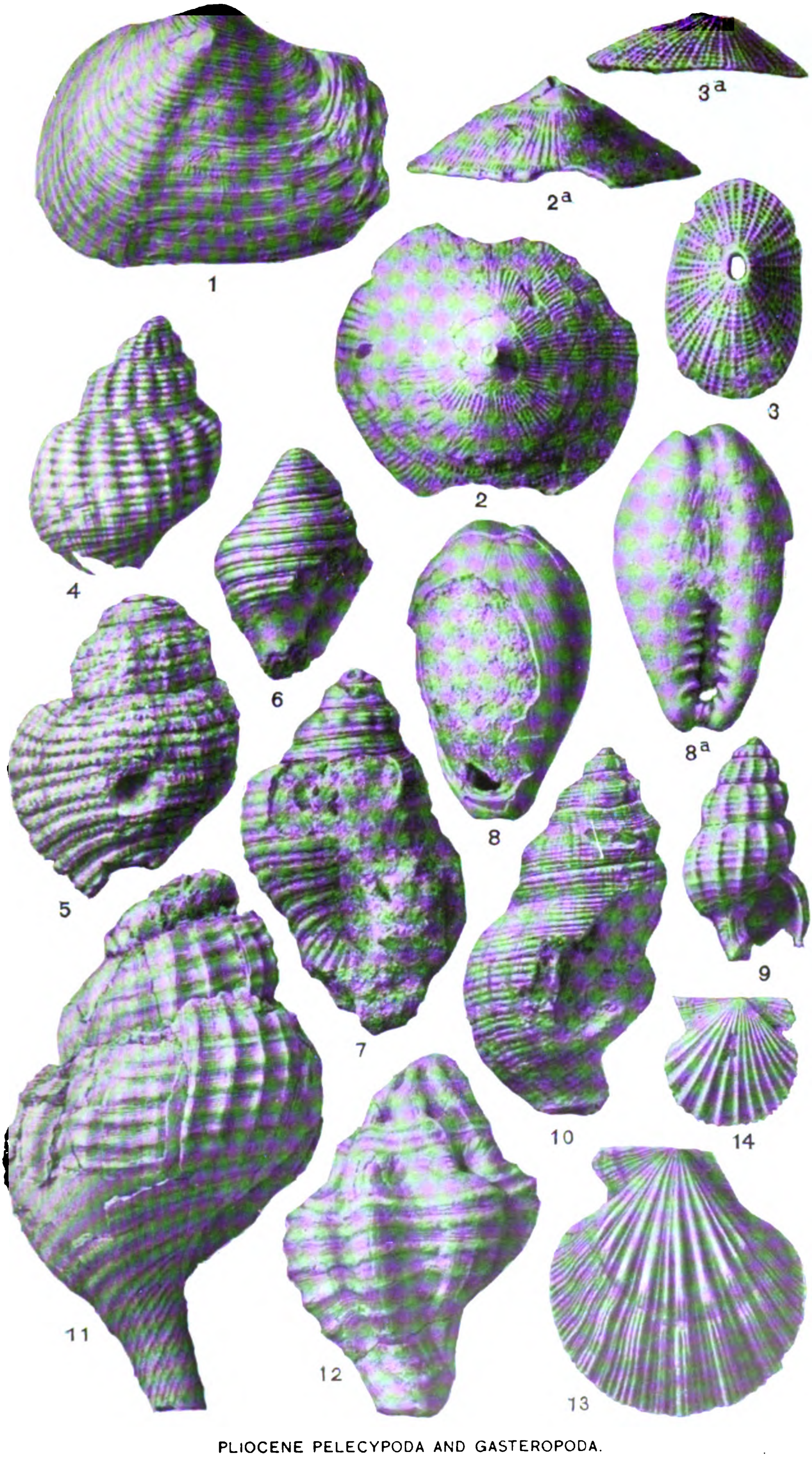
FIG. 10. *Chrysodomus* cf. *arnoldi* Rivers. U.S.N.M. 164962. Back view of imperfect specimen. Same locality as fig. 1. Known also from the Pleistocene of San Pedro, Los Angeles County.

FIG. 11. *Priene oregonensis* Redfield var(?) *angelensis* Arnold. U.S.N.M 164975. Back view of imperfect and slightly contorted specimen; longitude 71 mm. Same locality as fig. 3. Common in the lower Pliocene of the Pacific coast. It is the precursor of the Recent *Priene oregonensis* Redfield.

FIG. 12. *Murex eldridgei* Arnold. U.S.N.M 164955. Type. Back view; longitude 24 mm.; twice natural size. Known only from the same locality as fig. 1. Near the Recent *M. incisa* Broderip.

FIG. 13. *Pecten* (*Chlamys*) *hastatus* Sowerby var. *strategus* Dall. Collection of Delos Arnold. Left valve; altitude 36 mm. Pliocene, Santa Barbara. Also found in the Pliocene of southern California.

FIG. 14. *Pecten* (*Chlamys*) *bellilamellatus* Arnold. Type. Right valve; altitude 18 mm. Pliocene, Pacific Beach, San Diego. Known only from this horizon at this locality.



PLIOCENE PELECYPODA AND GASTEROPODA.

PLATE XLI.

TERTIARY TURRITELLAS.

(All figures natural size.)

FIG. 1. *Turritella pachecoensis* Stanton. U.S.N.M. 165002. Back view of imperfect specimen; altitude 59 mm. Eocene, Rock Creek, Los Angeles County. This species is supposed to be characteristic of the Martinez formation (lower Eocene.)

FIG. 2. *Turritella uvasana* Conrad. U.S.N.M. 164974. Wax cast, back view; altitude 41 mm. Sespe Canyon, Ventura County. Supposed to be characteristic of the Tejon formation (middle Eocene).

FIG. 3. *Turritella uvasana* Conrad. U.S.N.M. 165004. Back view of imperfect specimen; altitude 44 mm. Eocene, Rose Canyon, San Diego County.

FIG. 4. *Turtriella ineziana* Conrad (+ *T. hoffmanni* Gabb). U.S.N.M. 164964. Lower Miocene, supposed equivalent of the Fourfork formation, Chaffee Canyon, southwest of Piru, Ventura County. Supposed to be characteristic of the lower Miocene; found from San Mateo to San Diego counties.

FIG. 5. *Turritella ineziana* Conrad. U.S.N.M. 164969. Back view of imperfect specimen; altitude 36 mm. Tar Creek, north of Fillmore, Ventura County. Common in the Vaquers formation, but good specimens are hard to obtain.

FIG. 6. *Turritella ineziana* Conrad var. *sespeensis* Arnold. U.S.N.M. 164970. Type. Aperture view of imperfect specimen; altitude 34 mm. Same locality as fig. 5.

FIG. 7. *Turritella ocoyana* Conrad. U.S.N.M. 164990. Back view of imperfect large specimen; altitude 60 mm. Topanga Canyon, 3 miles south of Calabasas, Los Angeles County. Supposed to be characteristic of the lower Miocene. Common in central and southern California.

FIG. 8. Same species and locality as fig. 7; altitude 58 mm.

FIG. 9. Same species and locality as fig. 7; altitude 32 mm.; upper whorls.

FIG. 10. *Turritella variata* Conrad, U.S.N.M. 164991. Back view of imperfect specimen; altitude 34 mm. Same locality as fig. 7. Supposed to be characteristic of the lower Miocene; so far known only in Fresno County and south.

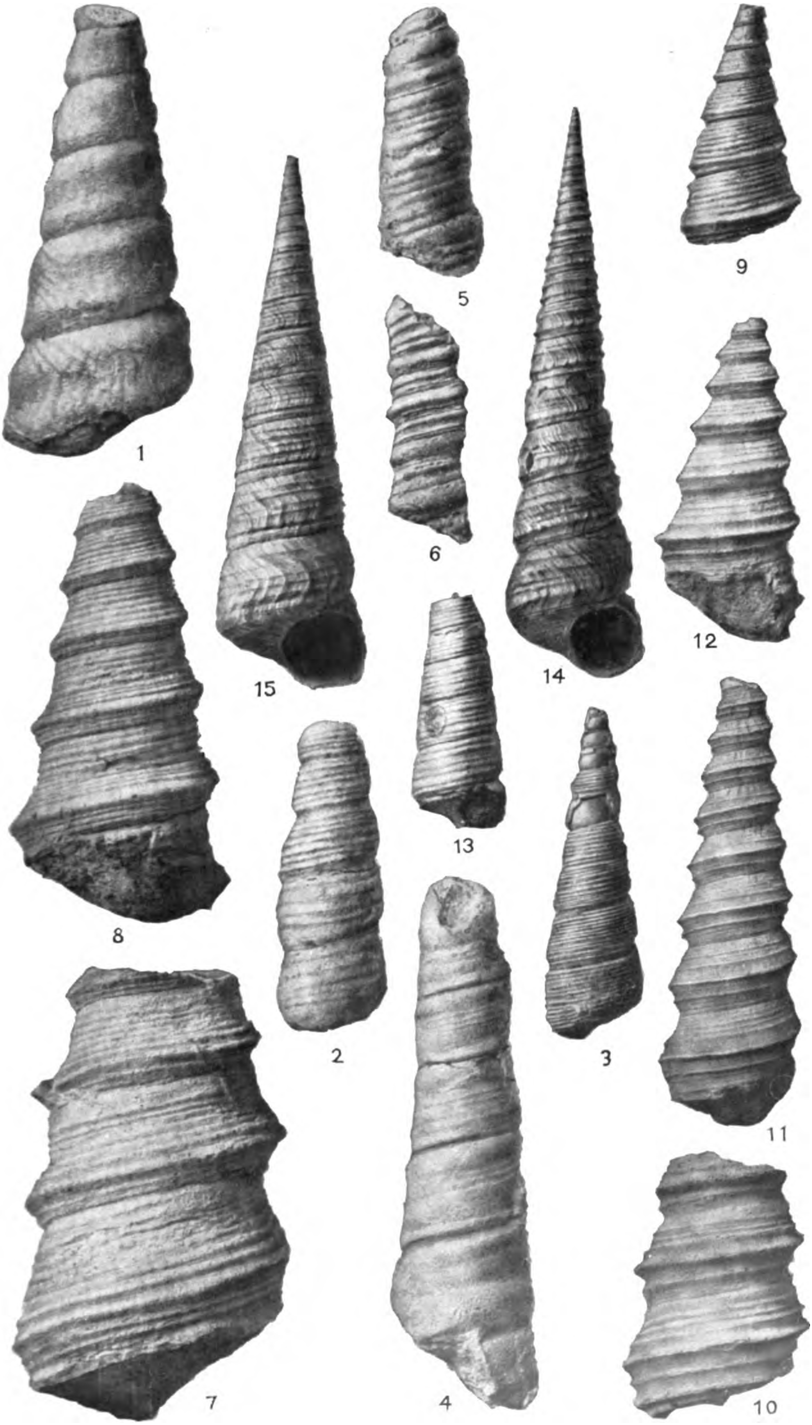
FIG. 11. Same species and locality as fig. 10. Slender variety; altitude 59 mm.

FIG. 12. Same species and locality as fig. 10. Broad variety; altitude 43 mm.

FIG. 13. *Turritella cooperi* Carpenter (var.?) *fernandoensis* Arnold. U.S.N.M. 164957. Type. Aperture view of imperfect specimen; altitude 31 mm. Lower Pliocene, Fernando formation, Elsmere Canyon, near Newhall, Los Angeles County. A common form in the lower Pliocene of southern California.

FIG. 14. *Turritella cooperi* Carpenter. Collection of Delos Arnold. Aperture view of typical form. Lower Pleistocene, lower San Pedro formation, Deadman Island, San Pedro, Los Angeles County. Common in the Pliocene and lower Pleistocene from Ventura County southward.

FIG. 15. *Turritella jewetti* Carpenter. Collection of Delos Arnold. Typical form, aperture view; altitude 70 mm. Same locality and horizon as fig. 14; geologic and geographic range also about the same.



TERTIARY TURRITELLAS.

INDEX.

Figures in *italic* denote illustrations of fossils.

A. Page.

- Acknowledgments to those assisting 1, 102, 138, 203
- Acmæa pelta Eschscholtz 27
  - sp 17
- Actæon (Rictaxis) punctocœlata Carpenter. 37
- Adams Canyon, fossils near 26
  - oil wells in 4, 42, 45
    - oil of, analyses of 209, 211, 212
  - rocks in 43, 49
- Agasoma barkerianum Cooper 147
  - kernianum Cooper 147
- Aliso Canyon, oil wells in 4, 42, 45, 49
- Amauropsis alveatus Conrad *224*
- Amiantis callosa Conrad 25, *250*
- Amusium lompocensis Arnold *230*
- Analyses of oil 209–217
  - methods of 205–208
- Anatina sp 11
- Angulus buttoni Dall 27
- Anomia lampe Gray 27
- Antisell, Thomas, explorations of 138. 139
  - on bituminous effusions 140
- Arca 247
  - camuloensis Osmont 24, *246*
  - labiata Sowerby 26
  - multicostata Sowerby 107, 152, *248*
  - montereyana Osmont 146
  - trilineata Conrad 25, 107, *248*
- Arnold, Ralph, bibliography compiled by. 199–202
  - fossils determined by 12, 14, 17, 25, 26
  - on fossils of oil-bearing formations... 219–254
  - on Los Angeles oil field 138–198
  - on physical and chemical properties of southern California oils 203–218
- Asphaltum, description of 139–141
- Astarte sp 152
- Astrodapsis whitneyi Conrad 26
- Astyris gausapata Gould 27, 107
  - gausapata var. carinata Hinds 27
  - richthofeni Gabb 26

B.

- Balanus concavus Bronn 13, 27, *236*
  - sp 14
- Baptist College area, oil wells in, geology of 175–178
  - oil wells in, records of 177, 178
- Bard Oil and Asphalt Co., wells of 46
- Bardsdale Crude Oil Co., wells of 10, 78, 79
- Bardsdale oil field, gas in 79
  - geology and structure of 76–79
  - location of 76
  - oil wells of 79–80
    - oil of, analyses of 209, 211, 212, 214–215

Page.

- Barlow's ranch, fossils from 27
- Basalt, occurrence and description of 150
- Basement rocks, character and distribution of 5
  - oil in 5
- Bibliography of southern California oils.. 199–202
- Big Sespe Canyon, location of 4
  - *See also* Sespe oil fields.
- Bison sp 154
- Bittium asperum Gabb 26, 27, 153
  - sp 147
- Bitumen, description of 139, 140–141
- Blake, W. P., explorations of 138
  - on oil 139
- Brea, occurrence and description of 134, 139–141, 154–155, 157, 187, 194
- Brea Canyon field, geology of 120–121
  - location of 120
  - oil wells of 123–125, 133
    - oil of, analyses of 210, 212, 213–215
  - structure of 121–123
  - tankage in 134
  - view of 120
- Brea Canyon Oil Co., wells of 123–124
  - wells of, oil of, analyses of 210, 212, 213
- Brea Ridge, rocks on 106, 125
- Brush Mountain, rocks of 34
  - structure at 34
- Buccinum sp 152
- Buckhorn Oil and Transportation Co., wells of 69
  - wells of, oil of, analyses of 209, 211. 212
- Bulla punctulata A. Adams 107
- Bulla wells, rocks near 113
- Bulloid sp 24
- Burrows & Sons, oil wells of, oil of, analyses of 209, 211, 212

C.

- Cadulus fusiformis Sharp and Pilsbry 27
- Cahuenga Pass, rocks at and near 150
- Calabasas, fossils near 147
- California, index map of southern part of.. 2
  - oil of. *See* Oil.
- California Oil Co., well of 98
- Calliostoma costatum Martyn 107, 153
  - sp 26. 147
- Callista (Amiantis) callosa Conrad *250*
  - diabloensis Anderson 147
  - subdiaphana Carpenter 24, 25, *250*
- Camulos, fossils near 24
- Cancellaria condoni Anderson 147, *226*
  - fernandoensis Arnold 25, *252*
  - tritonidea Gabb 27, 153
  - sp 24, 107

Page.

- Canis indianensis........ 154
    - sp........ 154
- Carcharodon rectus Agassiz........ 153
- Cardium breweri Gabb........ *224*
    - cooperi Gabb........ *232*
    - corbis Conrad........ 26,107
    - procerum Sowerby........ 26
    - linteum Conrad........ 11
    - quadrigenarium Conrad var. fernandoensis Arnold........ 25,27,107,*248*
    - sp........ 17,24,147
- Castac Creek, character of........ 3
- Central field, development of........ 158-159,172
    - geology of........ 165-170
    - location of........ 165
    - oil wells of........ 167-169,172
        - oil of, analyses of........ 210,211,213
        - records of........ 168,169
    - section across, figure showing........ 171
    - structure of........ 170-171
    - topography of........ 165
    - view of........ 168
- Central Oil Co., pipe line of........ 135
    - wells of........ 101
        - oil of, analysis of........ 210,212,213
        - view of, Murphy wells and........ 112
- Cerithidea californica Haldeman........ 153
- Cerithium topangensis Arnold........ 147,*226*
- Chaffee Canyon, fossils from........ 17
    - rocks of........ 80
- Chaffee syncline, description of........ 80-81
- Chama exogyra Conrad........ 153
- Chandler wells, location of........ 114
- Chino field, location of........ 132
    - oil in........ 110,132
- Chino Oil Co., wells of........ 132
- Chione fluctifraga Sowerby........ 107
    - mathewsoni Gabb........ 26
    - succincta Valenciennes........ 27
    - temblorensis Anderson........ 14,147,*232*
    - whitneyi Gabb........ 26
    - sp........ 14,146
- Chlamys bellilamellatus Arnold........ *252*
    - calkinsi Arnold........ *224*
    - hastatus Sowerby var. strategus Dall........ *252*
    - latiauritus Conrad........ *244*
    - opuntia Dall........ *244*
    - parmeleei Dall........ *244*
    - sespeensis Arnold........ *234*,*238*
    - wattsii Arnold........ *242*
- Chlorostoma (Omphalius) dalli Arnold........ 147
    - dalli var. inornatus Arnold........ *226*
        - var. subnodosus Arnold........ *226*
    - funebrale A. Adams........ 27
    - sp........ 24
- Chorus belcheri Hinds........ 26,27
- Chrysodómus arnoldi Rivers........ 25,*252*
    - sp........ 24
- Clampitt, E. A., oil well of, oil of, analysis of........ 210,211,213
- Clathurella conradiana Gabb........ 153
- Clidiophora punctata Conrad........ 26
- Coldwater anticline, location of........ 31,51,54
    - oil in........ 33,54
    - rocks in........ 7,8,55
- Colegrove, brea near........ 154
    - oil field near........ 158
        - wells of, geology of........ 182-184
            - records of........ 183-184
- Columbella (Astyris) gausapata Gould........ 27
    - var. carinata Hinds........ 27
- Columbia Oil and Producing Co., wells of........ 30,128
    - wells of, oil of, analyses of........ 210,212,213
- Columnar section, figure showing........ 144
- Consolidated Crude Oil Co., well of, oil of, analysis of........ 210,211,213
- Conus californicus Hinds........ 24,107
    - sp........ 24
- Cooper, H. N., analyses of........ 209-213
    - on methods of analyses of oil........ 205-206
- Cooper, J. G., fossils determined by........ 11,26,152
- Corbula luteola Carpenter........ 153
    - sp........ 11,24
- Correlations, table of........ 143
- Coyote Hills, rocks in........ 106,109
- Coyote Hills anticline, description of........ 109
- Cracks, joint, occurrence of........ 157
- Crepidula adunca Sowerby........ 27
    - princeps Conrad........ 26,153
    - rugosa Nuttall........ 27,107
- Crown King well, location of........ 75
- Cryptoyma californica Conrad........ 25,26,27,153
- Crystalline schist, oil in........ 100-101
- Cylichna alba Brown........ 27
    - costata Gabb........ *224*
    - sp........ 147
- Cypræa fernandoensis Arnold........ *252*

D.

- Davis and Harrison, oil wells of, oil of, analyses of........ 210,211,213
- Dentalium cooperi Gabb........ 11
    - hexagonum Sowerby........ 27
    - neohexagonum Sharp and Pilsbry........ 107
    - semipolitum Broderip........ 26
    - sp........ 14,107
- Devils Gate, oil wells near........ 54-55
- Dewitt Canyon, oil wells in........ 4,95
- Diabase, occurrence of........ 106
- Diplodonta orbella Gould........ 153
- Dolichotoma carpenteriana Gabb........ 25
    - keepi Arnold........ 147,*236*
- Donax levigata Deshayes........ 27
- Dosinia ponderosa Gray........ 24,147,*238*
    - sp........ 17
- Drillia hemphilli Stearns........ 27
    - inermis Hinds........ 27
    - inermis var. penicillata Carpenter........ 27
    - sp........ 147,153,*228*

E.

- East Canyon, oil wells in........ 96
- Eastern field, development of........ 159,164-165
    - geology of........ 160-162
    - location of........ 160
    - oil wells of........ 160-162,164-165
        - oil of, analyses of........ 210,211,213
        - records of........ 162
    - structure of........ 163-164
    - topography of........ 160
    - view of........ 165

Page.
Echinarachnius excentricus Eschscholtz. 24, 26, 27
Echinoidea *231, 233*
Edgemont, rocks near 145, 146
Eldridge, G. H., fossils collected by 26
  on Puente Hills oil district 102-137
  on Santa Clara Valley oil district 1-101
  work and death of .... xi, 138, 141-142
Elephas 154
Elkin's ranch, fossils near 17
Elsmere anticline, description of 97
  oil in 98
Elsmere Canyon, fossils from 25
  oil wells in 99
    oil of, analyses of 209-211, 213
Elsmere oil field, geology and structure of.. 97-98
  location of 4, 96
    wells of 98-101
      oil of, analyses of 214-215
      view of 48
Elsmere Ridge, oil wells on 99
  view of 48
Elysian Park anticline, description of. 155-156, 163
  oil in 156-157
Elysian Park hills, rocks of 145-146, 149, 160
Empire Oil Co., wells of 50
Enterprise well, data on 97
Eocene fossils *223, 225*
Equus 154
Eulima micans Carpenter 27
  hastata Sowerby 27
Eureka Canyon, oil field in, geology and structure of 80-86
  oil field in, location of 80
    wells of 4, 87-89
      log of 88
  rocks in 81-83
Eureka Ridge, rocks of 82

F.

Faults, occurrence of 29, 30-31, 34, 35
  See also particular districts.
Fernando formation, age and character of.. 22-23, 106, 150-152
  correlation of 22, 23, 24
  distribution of.... 22-23, 43, 49, 52-53, 66-68, 75, 77-78, 81-84, 91-93, 97, 106, 113, 115, 118, 120-123, 125-131, 144, 152, 173-174, 186
  fossils of 23-28, 107, 152
  oil in 45, 86, 98, 99, 110-113, 115, 126, 193
Fernando Pass, fossils from 25
Fissuridea murina Carpenter 107, 152, *252*
Foot-of-the-Hill wells, data on 58 60
  fossils near 13
  map of 59
Fortuna wells, data on 69-70
  map of 70
  view of 70
Fossils, character and distribution of. 11-17, 24-28, 107, 146-148, 152-153, 219-220
  plates showing 223-255
Fourfork Creek, oil wells on 12, 60-61
  oil wells on, map of 60
  rocks on 13
Fourfork wells, oil of, analyses of 216-217
Freeman and Nelson, oil wells of 98, 100
Fryers Peak, section through, figure showing 92
Fuel, use of oil for 135, 204
Fullerton Oil Co., wells of 128
Fusus barbarensis Trask 107
  remondii Gabb *224*
  rugosus Trask 24
  sp 14, 147

G.

Galerus inornatus Gabb 26
Garberson Canyon, prospecting in 4
  well in 79-80
Gas, analysis of 204
  occurrence of 134
Gas making, use of oil for 204
Gasteropoda 107, 147, *225, 229, 233, 235, 237, 239, 249, 253*
Geologic formations, correlation table of... 143
  descriptions of 4-29, 103-107, 143-155
Geologic maps. *See* Map, geologic.
Geology. *See* Geologic formations: Structure: *particular oil fields.*
Glycymeris barbarensis Conrad 153
  intermedia Broderip 26
  veatchii Gabb var. major Stanton *224*
  sp 147
Goat Mountain, fossils from 26
Graham-Loftus Oil Co., wells of 129, 130
Granite, occurrence and description of 145
Granitic basement, character and distribution of 5
  oil in 5
Grimes Canyon, fossils near 17
  oil wells in 4
  rocks in 78

H.

Hamlin, Homer, Fernando formation named by 22
  fossils determined by 152
Happy Thought wells, data on 58
Hinnites giganteus Gray 17, 153, *256*
Hipponyx cranioides Carpenter 26
Holser anticline, description of 67-68
  oil in 68
Holser Canyon, oil wells in 75
Home Oil Co., wells of, oil of, analysis of... 210, 212, 213
  rocks near 112, 113
Hoover street, Los Angeles, section along, figure showing 175
Hopper anticline, description of 64
  oil in 67
Hopper Canyon, oil wells in 4, 34-35, 65, 68-70
  oil wells in, oil of, analyses of 20, 211, 212
  rocks in 18, 53
  structure at 32
  views in 2, 70
Hopper-Piru oil fields, faults in 65
  location of 4, 64
  oil wells of 64 68
  structure of 68-75

I. Page.

Ivers anticline, location of.................. 51,56
  oil wells on.............................. 51
Ivers wells, data on........................ 55-56
  location of, map showing............... 55

K.

Kellia suborbicularis Montague............ 153
Kentuck wells, data on...................... 56-58
  location of, map showing............... 57
  oil of, analysis of..................... 216-217
  structure at.......................... 33,56-57

L.

La Brea Rancho Oil and Asphalt Co., well of, oil of, analyses of......... 210,211,213
La Habra Canyon, oil field in, geology of.. 115
  oil field in, location of.................. 115
    structure of........................ 116-117
    wells in............................ 117
      oil of, analyses of......... 210,211,213
  rocks in.................................. 106
Lacuna compacta Carpenter................ 27
  solidula Loven........................... 26
  sp.. 27
Lævicardium centifilosum Carpenter....... 26
Lake Shore avenue, Los Angeles, section along, figure showing........... 171
Langdell, Newmark and Roan, oil wells of. 40
Laqueus californicus Koch.................. 153
Laughlins Hill, rocks of.................... 150
Leda gabbi Conrad......................... 11
  taphria Dall................... 24,107,146,*248*
  sp................................... 11,14,27
Lima hamlini Dall........................... 152
Lion Canyon, bitumen in..................... 29
  oil wells in.............................. 40
  rocks in.......................... 9-10,28-29
Lion Canyon fault, location of............. 38
Lion Hill, faults at......................... 38
  oil wells on.............................. 40
  rocks in.................................. 38
Literature on southern California oils.... 199-202
Lithophagus plumula Reeve................ 153
Little Sespe Creek, canyon of, oil wells in.. 4
  canyon of, oil wells in, oil of, analyses of...................... 209,211,212
  fossils on and near...................... 13
  oil wells on............................. 58
    map showing.......................... 59
  rocks on................................. 13
  See also Sespe oil fields.
Littorina scutulata Gould................... 27
Los Angeles, fossils in and near...... 147,152-153
  oil in and near. *See* Los Angeles oil district.
  rocks near............................... 148
Los Angeles anticline, description of..... 184-185
Los Angeles district, brea in...... 139-141,153-154
  columnar section in, figure showing..... 144
  correlation in............................ 143
  explorations in.......................... 138-142
  folds and faults in...................... 155-157
  future development of................. 196-197
  geologic formations in................. 143-155
    map showing.......................... 144
Los Angeles district, lagoon in, view of . . 188
  location of.............................. 142
  map of................................... 158
  Miocene sandstone in, view of.......... 166
  oil of................................. 203-217
    analyses of.......................... 210-217
    gravity of............................ 203
  oil derricks in, removal of............ 159-160
  oil fields of.......................... 156-157
    descriptions of..................... 158-195
    development of.................... 158-160
    location of........................... 158
  oil prospects in southwest and west of . 197
  oil wells of......... 162,167-169,174-184,187-193
    location of, map showing............. 158
  Pliocene sandstone in, view of.......... 188
  production of............................ 198
  sections in, figures showing.............. 171, 175,178,181,189
  storage in............................... 198
  structure of........................... 155-157
    sections of, plate showing.......... 162
  topography of......................... 142-143
  transportation of oil in................. 198
  See also Central, Eastern, Western, *and* Salt Lake fields.
Los Angeles Pacific Rwy. Co., wells of, oil of, analyses of............... 209,211,212
Los Angeles Rwy. Co., well of, oil of, analyses of...................... 210,211,213
Los Angeles River, oil prospects east of.... 196
Los Angeles wells. *See* Foot-of-the-Hill wells.
Lower Ojai Valley, section across, figure showing............................ 9
  See also Ojai Valley.
Lunatia lewisii Gould........................ 24,26
Lyon, L. H., wells of........................ 71
Lyons anticline, description of............. 65-66
  oil in.................................... 67
Lyropecten ashleyi Arnold.................. *240*
  bowersi Arnold.......................... *226*
  crassicardo Conrad...................... *234*
  estrellanus Conrad...................... *228*
  magnolia Conrad......................... *228*
  vaughani Arnold......................... *238*

M.

Macintosh well, oil of, analyses of........ 216-217
McKittrick district, oil wells of............ 109
Macoma indentata Carpenter................ 25
  inquinata Deshayes..................... 153
  nasuta Conrad....................... 27,147,153
  secta Conrad............................ 24
  sp................................ 25,26,27,152
Macron merriami Arnold.................... 147,*228*
Mactra californica Conrad.................. 153
  catilliformis Conrad.................... 27
  hemphilli Dall.......................... 25
Maltman well, oil of, analyses of.......... 216-217
Mangilia angulata Carpenter............... 27
  sp....................................... 24
Manley (M.) & Co., oil well of, oil of, analysis of...................... 210,211,213
Map of Los Angeles district................ 158

Page.
Map of Puente Hills district 110
  of Santa Clara Valley 36
Map, geologic, of Los Angeles district 144
  of Puente Hills 102
  of Santa Clara Valley Pocket.
Map, index, showing location of oil fields 2
Margarita sp 26
Matilija Creek, hot springs on 3
Menges Oil Co., wells of 123, 124
Meretrix californiana Conrad 11
  hornii Gabb *222*
Merriam, J. C., fossils determined by 24
  on Fernando fossils 23
  on Los Angeles brea fossils 154
Metis alta Conrad 24, 26, 107
Miocene basalt, occurrence and description of 150
Miocene fossils *227*, *229*, *231*, *233*, *235*, *237*, *239*
Miocene sandstone, views of 166
Mitra maura Swainson 26, 153
Modelo anticline, description of 64–65, 71–72
  location of 32, 34
  oil in 34–35, 65, 67, 69
Modelo Canyon, bitumen in 20
  oil wells in 4, 18, 65, 71–74
    oil of, analyses of 209, 211, 213–215
    records of 73
    view in 70
  rocks in 18, 64–65
Modelo formation, bitumen in 20
  burning of 22
  character of 17, 20–21
  correlation of 18, 20–22
  distribution of 17–21, 37, 42–43, 47, 49, 53, 62–63, 64–67, 77, 81–86
  faults in 37, 44
  fossils in 20, 37
  Monterey formation and, relations of 17
  oil in 18, 20, 34, 40, 41, 45–46, 69, 71–74, 86
  subdivisions of, description of 18–20
  Vaqueros formation and, relations of 13, 19–20
Modelo Oil Co., wells of 34, 72–74
  wells of, logs of 73
    oil of, analyses of 209, 211, 213
    view of 70
Modelo syncline, location of 32
Modiolus fornicatus Carpenter 27
Modiolus ornatus Gabb 222
  rectus Conrad 25, 26, 107
  sp 12, 27
Monia macroschisma Dall 25
Monoceros engonatum Conrad 27
  lugubre Sowerby 26
Monterey formation, correlation of Modelo and 18, 20–21
  correlation of Puente and 105
  fossils in 21
Morio (Sconsia) tuberculatus Gabb *224*
Murex eldridgei Arnold 25, *252*
  monoceros Sowerby 26
Murphy Oil Co., pipe line of 135
  wells of 111
    oil of, analysis of 204
    view of Central wells and 112
Mya truncata Linné 25, *252*

Page.
Mylodon sp 154
Mytilus mathewsonii Gabb var. expansus Arnold 14, , 17, 147, *232*

N.

Nassa californiana Conrad 24, 26, 27, 153
  cretacea Gabb 11
  fossata Gould 27, 107, 153
  hamlini Arnold 152, *252*
  mendica Gould 27, 153
    var. cooperi Forbes 26
  perpinguis Hinds 26, 27, 107, 153
  sp 14
Natica sp 147
Neæra dolabriformis Gabb 11
Neptunea altispira Gabb 26
  humerosa Gabb 25
Nettleton and Kellerman, oil wells of 98, 99
Neverita callosa Gabb 147, *234*
  recluziana Petit 25, 28, 107, 152, 153, *248*
    var. alta Dall 28
  sp 14, 147
New Camulos well, location of 75
New Century Oil Co., oil wells of 98, 100
New England Oil Co., wells of 117
  rocks near 116
Newhall, rocks near 22
  wells near, location of, map showing 100
    view of 48
Newhall district, subdivisions of 90
Newhall well, data on 96
Nigger anticline, location of 35
  oil wells on 35
Nigger Canyon, oil wells in 4, 71
Nordhoff, location of 36
  oil wells near 39, 40
North Whittier Oil Co., wells of 114–115
Nucula castrensis Hinds 24
  solitaria Gabb 11
  truncata Gabb 11
  sp 24

O.

Oak Ridge, elevation of 3
  fossils on 17
  oil wells on 4
  rocks of 10, 15, 20–22, 53, 78–79, 85
  view of 46
Oak Ridge-South Mountain anticline, description of 77–79
  oil wells on 79–80
Oat Mountain, rocks on 13, 53
  structure of 31, 63
Ocinebra lurida Middendorf 153
  topangensis Arnold 147, *232*
Odostomia gouldii Carpenter 28
  nuciformis var. avellana Carpenter 28
  tenuis Carpenter 28
Ohio, oil of, composition of 204
Oil, associates of 134
  analyses of 209–217
    methods of 205–208
  character of 133, 203–217
    See also particular wells.

Page.

- Oil, color of 203
  - composition of 204
  - geologic relations of 109-110, 132-133
  - gravity of 203
  - occurrence of, north of Santa Clara River 32-35
  - prices of 136
  - production of 136, 198
  - products of 205
  - storage and transportation of 134-135, 198
  - utilization of 135-136, 204
- Oil companies, list of 137, 195
- Oil fields, descriptions of ... 36-101, 110-132, 158-198
  - location of 4, 36, 110, 158
    - map showing 2
- Oil refineries, list of 218
  - products of 205, 218
- Oil wells, location of, maps showing ... 36, 110, 158
  - yield of 133-134
- Ojai Oil Co., wells of 48
- Ojai Valley, description of 3
  - faults in 3, 30-31, 36-39
  - fossils in 14, 21, 37
  - oil fields in, description of 36-42
    - location of 4, 36
    - oil of, analyses of 209, 211, 212, 214-215
  - rocks in 9, 13-15, 20, 29
  - structure of 30-31, 36-39
  - *See also* Upper Ojai Valley; Lower Ojai Valley.
- Olinda field, fault in 126
  - geology of 104, 125
    - section showing 130
  - location of 125
  - oil wells in 131-133, 203
    - oil of, analyses of 210, 212, 213-215
  - structure in 126-131
  - plate showing 130
  - tankage in 134
  - view of 124
- Olivella biplicata Sowerby 28
  - intorta Carpenter 25, 26, 28
  - pedroana Conrad 28
  - sp 27
- Omphalius dalli var. inornatus Arnold *226*
  - dalli var. subnodosus Arnold *226*
- Ostrea eldridgei Arnold 17, *230*
  - idriaensis Gabb 12
  - titan Conrad 17, 147, *226*, *236*
  - veatchii Gabb 24, 107, 152, 153
  - sp 14
- Oxyrhina plana Agassiz 153
  - tumula Agassiz 153

P.

- Pachypoma sp 24
- Pacific Coast Oil Co., wells of 94, 96, 98, 99
  - wells of, oil of, analyses of 209-211, 213
- Paleontology. *See* Fossils.
- Panopea generosa Gould 17, 25, 26, 146
- Park Crude Oil Co., well of, analysis of 210, 211, 213
- Parke, J. G., explorations by 139
- Pasadena, fossils from 146
- Patinopecten caurinus Gould *244*
  - healeyi Arnold *240*

Page.

- Pearl Oil Co., wells of 98-99
  - wells of, oil of, analysis of 209, 211, 213
- Pecten *241*, *243*, *245*
  - (Lyropecten) ashleyi Arnold 152, *240*
  - auburyi Arnold 153, *242*
  - bellus Conrad 24, *242*
  - (Lyropecten) bowersi Arnold 147, *226*
  - (Patinopecten) caurinus Gould 25, *244*
  - (Chlamys) calkinsi Arnold 11, *224*
  - (Plagioctenium) cerrosensis Gabb 24, *242*
  - (Plagioctenium) circularis Sowerby *242*
  - (Lyropecten) crassicardo Conrad .. 14, 147, *234*
  - (Lyropecten) estrellanus Conrad *228*
    - var. catalinæ Arnold 25
  - (Hinnites) giganteus Gray 17, *236*
  - (Chlamys) hastatus Sowerby var. strategus Dall *252*
  - (Patinopecten) healeyi Arnold 25, 153, *240*
  - (Propeamusium) interradiatus Gabb .. 11, *224*
  - (Chlamys) latiauritus Conrad 152, *244*
    - var. monotimeris Conrad 28
  - (Amusium) lompocensis Arnold 14, *230*
  - (Lyropecten) magnolia Conrad 14, *228*
  - martinezensis Gabb 11
  - merriami Arnold 24, *244*
  - miguelensis Arnold 147
  - (Chlamys) opuntia Dall 152, *244*
  - (Chlamys) parmeleei Dall 25, *244*
  - (Pseudamusium) peckhami Gabb .. 21, 105, *234*
  - (Pseudamusium) pedroanus Trask 21, 105, 147, 153, *244*
  - (Chlamys) sespeensis Arnold ... 12, 13, *234*, *238*
    - var. hydei Arnold 13, 17
  - stearnsii Dall 152, 153, *242*, *244*
  - (Lyropecten) vaughani Arnold 14, *236*
  - vogdesi Arnold *242*
  - (Chlamys) wattsii Arnold *242*
- Pelecypoda 107, 147, *223*, *225*, *227*, *229*, *231*, *233*, *235*, *237*, *239*, *249*, *251*, *253*
- Pennsylvania, oil of, composition of 204
- Periploma discus Stearns 153
- Petricola carditoides Conrad 153
- Petroleum. *See* Oil.
- Phacoides acutilineatus Conrad 25, 107, 146
  - californicus Conrad 107, 153
  - childreni 147
  - nuttallii Conrad 107
  - richthofeni Gabb 107, 147, *236*
  - sp 14, 17, 24
- Pholadidea penita Conrad 27
- Pico anticline, description of 90-92
  - location of 36
  - oil wells in 92, 95
  - view of 90
- Pico Canyon, oil wells in 4, 94-95
  - oil wells in, oil of, character of 4
    - oil of, analyses of 209, 211, 213, 216-217
  - overturn in, view of 90
  - rocks in 17
  - views in 90
- Pico oil field, geology and structure in 90-94
  - location of 90
  - subdivisions of 93-94

Page
- Pico oil field, wells in.................... 94-96, 203
- Pine Mountain, elevation of................ 2
- Pioneer well, data on....................... 100
- Pipe lines, length and distribution of..... 135, 198
- Pirie ranch, oil wells at..................... 39-40
- Piru Creek, canyon of, Fernando formation at.............................. 23
  - canyon of, oil wells in................. 4, 74-75
    - structure in........................ 32
    - *See also* Hopper-Piru fields.
  - character of............................ 3
  - fossils on.............................. 24
  - rocks on................................ 23
  - structure east of....................... 67-68
- Piru Oil and Land Co., wells of............ 74-75
- Piru River, view of........................ 2
- Pisania fortis Carpenter var. angulata Arnold.......................... 25, *252*
- Placerita Canyon, oil wells in...... 4, 100-101, 203
  - oil wells in, location of, map showing... 100
    - oil of, analysis of.................. 214-215
- Placunanomia sp........................... 13, 153
- Plagioctenium cerrosensis Gabb............ *242*
  - circularis Sowerby....................... *242*
- Platyodon cancellatus Conrad............... 153
- Pleistocene deposits, distribution and description of.................... 28-29, 43, 91, 98, 107, 153-155, 173, 174, 186
- Pleurotoma (Dolichotoma) keepi Arnold... *238*
  - sp...................................... 152
- Pliocene fossils....... *241, 243, 245, 247, 249, 251, 253*
- Pliocene sandstone, view of................ 188
- Pole Canyon oil field, geology and structure of.............................. 62-63
  - location of............................. 62
- Priene oregonensis Redfield var. angelensis Arnold................. 24, 25, 107, *252*
- Propeamusium interradiatus Gabb........ *224*
- Proudfit and Parker, oil well of, oil of, analyses of..................... 210, 211, 213
- Prutzman, P. W., analyses by............ 214-215
  - on California oils....................... 142
- Psephis lordi Carpenter.................... 27
  - tantilla Gould........................... 26
- Pseudamusium peckhami Gabb............ *234*
  - pedroanus Trask.......................... *244*
- Puente fault, location and description of. 108-109, 111-113, 116, 119
- Puente field, geology of................... 117-118
  - location of............................. 117
  - oil wells of........................ 119, 133, 203
    - oil of, analyses of......... 210, 212, 213-217
  - structure of............................ 118-119
  - tankage in.............................. 134
- Puente formation, character of.......... 103-105, 145-146, 148-149
  - correlation of.......................... 105
  - distribution of....................... 103-105, 112-113, 115, 117-118, 121, 125-131, 144, 145-146, 148-150, 160, 173, 186
  - fossils in......................... 104, 146-148
  - oil in...... 110, 114, 119, 132-133, 149-150, 156, 187
  - subdivisions of......................... 103
- Puente Hills, altitudes in.................. 103
  - area in................................. 134

Page.
- Puente Hills, correlations in 143
  - development of....................... 132-133
  - gas in.................................. 134
  - geology of........................ 103-107, 143
    - map showing........................ 102
  - location of............................. 102
  - map of.................................. 110
  - oil of....................... 133-137, 203-217
    - analyses of........................ 209-217
    - gravity of......................... 133, 203
    - prices of........................... 136
    - production of....................... 136
    - storage and transportation of.... 134-135
    - utilization of...................... 135-136
  - oil-bearing strata of................... 109-110
  - oil companies of, list of............... 137
  - oil wells of.... 113-115, 117, 119, 123-125, 131-134
    - location of, map showing........... 110
    - yield of............................ 133-134
    - *See also particular wells.*
  - oil fields of, descriptions of........... 110-132
  - structure of............................ 108-109
    - sections of, plate showing.......... 108
  - topography of........................... 103
- Puente Oil Co., pipe line of................ 135
  - wells of............................ 119, 132
    - oil of, analyses of......... 210, 212, 213
- Pumping plant, view of..................... 120
- Purpura edmondi Arnold................ 147, *226*

R.

- Ramona Canyon, oil well in................ 68
- Ramona Oil Co., well of.................... 68, 75
- Raphetto Hills, oil prospects in............ 196
  - rocks of............................ 152, 196
- Reasoner syncline, description of........... 67
- Red beds, distribution of.................. 8-10, 47
  - faults in............................... 38
  - fossils in.............................. 11
  - gas in.................................. 39
  - occurrence of, in Sespe formation........ 8-10
  - oil wells in................ 10, 34, 39, 48, 55, 59
  - structure of, maps showing............. 55, 57
  - Vaqueros shale and, relations of....... 11
- Refineries. *See* Oil refineries.
- Rice, W. P., oil wells of.................... 96
- Rice Canyon, oil wells in.................. 4, 96
- Rictaxis punctocœlata Carpenter........... 27
- Ridge Crest, oil well near................... 99
- Road dressing, oil used for............... 135-136
- Rocks. *See* Geologic formation.
- Russell Company, wells of.................. 54

S.

- Salt Lake Company, oil wells of............ 159
- Salt Lake field, brea in..................... 187
  - development of........................ 159, 195
  - geology of............................. 186-193
  - location of............................ 158, 186
  - oil sands of........................... 186-193
    - section of, figure showing........... 189
  - oil wells in........................... 187-193, 195
    - oil of, analysis of........... 210, 211, 213
    - records of......................... 190-193
  - section in, figure showing............... 189

Page.
Salt Lake field, structure in.............. 193–195
  view of.................................. 168
Salt Lake flexure, description of.......... 193–195
  section through, figure showing........ 189
Salt Lake Oil Co., well of, oil of, analysis of.. 210, 211, 213
Salt Marsh Canyon, oil wells in 4, 42, 45–46
  oil wells in, oil of, analysis of..... 209, 211, 212
San Cayetano fault, location of............ 30–31, 44, 46, 47, 49, 52
  oil wells along.......................... 49
San Cayetano Mountain, fault center at.. 30–31, 44
  oil field near. *See* Santa Paula Ridge.
  rocks at................................. 23, 48
  See also Santa Paula Canyon.
San Cayetano wells, data on........... 68–69, 203
  location of.............................. 4, 68
San Fernando field, well in, oil of, analyses of...................... 209, 211, 213
San Gabriel Range, elevation of............ 3
  oil wells on............................ 96, 98, 99
  rocks in................................ 35, 97
  structure of............................ 35–36
  topography of........................... 2–3
San Juan Hill, altitude of................. 103
Sansinena wells, description of............ 117
Santa Ana Oil Co., oil wells of............ 98
  oil wells of, oil of, analyses of..... 209, 211, 213
Santa Barbara Forest Reserve, location of. 2
Santa Clara River, course of............... 1
  oil fields north of..................... 36–75
  oil fields south of..................... 76–101
  red beds south of....................... 10
  structure north of...................... 30–35
  structure south of...................... 35–36
  tributaries of.......................... 3
  valley of, oil field of. *See* Santa Clara oil field.
  Vaqueros formation south of 15–17
Santa Clara Valley oil field, correlations in. 21–22, 143
  fault in................................ 29
  geology of.............................. 4–29, 143
    map showing........................ Pocket
  map of.................................. 36
  oil of.................................. 203–217
    analyses of......................... 209–217
    gravity of.......................... 203
  oil fields of.......................... 4, 36–101
  oil wells of............... 39–42, 45–46, 48, 50, 54–62, 68–75, 79–80, 86–89, 94–96, 98–101
    location of, map showing.......... 36
  structure of........................... 29–36
    sections of, plates showing........ 28, 30
  topography of.......................... 1–4
Santa Fe Oil Co., wells of............ 128, 129, 130
  wells of, oil of, analyses of........ 210, 212, 213
Santa Felicia Creek, fossils on............ 24
Santa Monica Mountains, rocks on....... 145, 146
Santa Paula Canyon, fault center at.. 38, 44, 48, 50
  fault center at. *See also* San Cayetano Mountain.
  oil wells in, oil of, analyses of.......... 214–215
  rocks in................................ 47
  view of................................. 48
Santa Paula Creek, character of........... 3
  fossils from............................ 26
  rocks on................................ 49
Santa Paula Oil Co., oil wells of.......... 42
Santa Paula Ridge, oil field south of, faults in.................................. 50
  oil field south of, geology and structure of..................................... 49–50
  oil wells of............................ 50
  rocks of................................ 48
Santa Susanna Mountains, oil wells in...... 4
  rocks of....................... 15, 20–22, 43, 92
  view of................................. 46
Saugus, rocks near......................... 28, 29
Saxidomus aratus Gould..................... 28
  gibbosus Gabb........................... 153
  gracilis Gould.......................... 27
Scala crebricostata Carpenter.............. 28
  tincta Carpenter........................ 28
Schist, black, occurrence of............... 145
Schist, crystalline, oil in................ 100–101
Sconsia tuberculatus Gabb.................. 224
Scott and Loftus, oil well of.............. 196
Scutella fairbanksi Merriam........ 13, 17, 230, 232
Semele decisa Conrad....................... 153
  sp...................................... 26
Sespe Creek, canyon of, faulting in........ 52
  canyon of, oil in....................... 33
    oil wells in........................ 54–56
    Pleistocene near.................... 28
    section across, figure showing...... 8
  character of............................ 3
  region of............................... 2
    structure in........................ 31
  rocks on and near....................... 28, 30, 52
Sespe formation, character of.............. 7–12
  conglomerate in......................... 9
  detail of, section showing.............. 8
  distribution of............... 7–12, 51–52, 63, 78
  faults in............................... 38
  fossils in.............................. 11
  oil from........... 10, 12, 33, 54, 55, 58, 59, 61, 87
  subdivisions of, descriptions of........ 8–12
  Vaqueros shale and, relations of........ 11
Sespe oil field, location of............... 51
  oil wells in............................ 54–63
  structure of............................ 51–53
  view in................................. 2
Shields Canyon, oil well in................ 80
  prospecting in.......................... 4
Shirley, I. W., oil well of, oil of, analysis of.. 210, 211, 213
Sigaretus perrini Arnold................... 147, 228
Siliqua edentula Gabb...................... 107
  patula Dixon............................ 27
Siliquaria edentula Gabb................... 26
Silver Thread fault, location of........... 47, 48
  oil wells along......................... 48
Silver Thread oil field, fossils in........ 11
  location of............................. 4, 46
  oil wells in............................ 48
    oil of, analyses of......... 209, 211, 212, 214–215
  structure of............................ 46–48
Simi Valley, rocks in...................... 77
Sisar Creek, fossils from.................. 11

Page.

- Sisar Creek, rocks on ... 29, 47
- Sisar Creek oil field. *See* Silver Thread oil field.
- Smilodon sp ... 154
- Sobre Vista Oil Co., oil wells of ... 41–42
- Solen parallelus Gabb ... 11
  - rosaceus Carpenter ... 26
  - sicarius Gould ... 24, 107
- Soquel Canyon, rocks in ... 104, 125, 127–128
- South Mountain, elevation of ... 3
  - rocks in ... 15, 20, 77
- South Mountain–Oak Ridge anticline, description of ... 76–78
  - oil wells on ... 79–80
- Southern Sulphur Mountain field. *See* Sulphur Mountain.
- Spirocrypta pileum Gabb ... 11
- Spisula planulata Conrad ... 26
- Structure, account of ... 29–36, 108–109
  - sections of, plates showing ... 28, 30, 108, 130, 162
  - *See also particular oil fields.*
- Sulphur Canyon, fossils in ... 21
- Sulphur Mountain, altitude of ... 3, 42
  - faults at ... 38–39, 44–45, 63
  - oil field on, description of ... 42–46
    - geology of ... 42–43
    - location of ... 4, 42
    - oil wells in ... 45–46, 203
    - structure of ... 44
  - oil wells on ... 40
    - oil of, analyses of ... 209, 211, 212
  - rocks on ... 20, 38, 42–43, 47
- Sulphur Mountain fault, location of ... 63
- Sulphur Mountain Petroleum Co., well of ... 209, 211, 212
- Sulphur Peak, rocks at ... 54, 55
- Sunset Oil Co., wells of ... 34–35, 65, 69
- Syncline, oil in ... 33, 56–57

T.

- Tankage, amount and distribution of ... 134, 198
- Tapes staleyi Gabb ... 153
  - staminea Conrad ... 27
  - tenerrima Carpenter ... 25, 28
- Tapo anticline, description of ... 84, 91
  - location of ... 36, 82–83
  - oil wells in ... 89
- Tapo Canyon, oil field in, geology and structure of ... 80–86
  - oil field in, location of ... 80
    - wells of ... 4, 16, 89
  - rocks in ... 16
- Tar Creek, canyon of, oil wells in ... 4, 61–62
  - canyon of, oil wells in, oil of, analyses of ... 216–217
  - fossils from ... 12
  - rocks on and near ... 13, 18
- Telegraph Canyon, rocks in ... 131
- Tellina hoffmaniana Gabb ... 11
  - longa Gabb ... 11
  - parilis Gabb ... 11
  - idæ Dall ... 25, 26, 153
- Temple road. *See* Western avenue and Temple road.
- Terebra simplex Carpenter ... 28
- Terebratalia occidentalis Dall ... 153, *250*
  - smithi Arnold ... *250*
- Teredo sp ... *224*
- Tertiary fossils ... 255
- Texas, oil of, composition of ... 204
- Thompson Ridge, faults in ... 37–38
  - rocks in ... 37–38
- Thompson Ridge fault, location of ... 37
- Thracia semiplanata Whiteaves ... 11
  - sp ... 146
- Timber Canyon, oil well in, oil of, analysis of ... 209, 211, 212
- Topatopa anticline, description of ... 30
  - oil wells on ... 33, 34, 54
  - rocks of ... 33
  - view of ... 2
- Topatopa formation, age of ... 7
  - character of ... 5–6
  - distribution of ... 7, 46–47, 49, 51
  - oil of ... 7, 33
  - oil wells in ... 54, 55
- Topatopa Range, altitude of ... 3
  - structure of ... 30
- Topography, description of ... 1–4
- Tornatina culcitella Gould ... 28
  - harpa Dall ... 28
- Torrey anticline, description of ... 81–83
  - location of ... 36
- Torrey Canyon, fossils from ... 17
  - oil field in, geology and structure of ... 80–86
    - location of ... 80
    - wells in ... 86–87
      - oil of, analyses of ... 209, 211, 213–215
  - rocks in ... 16, 81–83
- Towsley Canyon, oil wells in ... 4, 95
- Tresus nuttalli Conrad ... 26, 27
- Triton gibbosus Broderip ... 26
- Tritonium sp ... 14, 25, *252*
- Trochita costellata Conrad ... 107, 148, *236*
  - filosa Gabb ... 25, *252*
  - inornata Gabb ... 148
  - sp ... 17
- Trophon multicostata Conrad ... 107
  - sp ... 13, 14, 147, 148
- Turbo topangensis Arnold ... 148, *228*
- Turbonilla laminata Carpenter ... 28
  - sp ... 11, 26, 28
- Turritella ... 254
  - cooperi Carpenter, var. fernandoensis Arnold ... 25, 27, 28, 107, *254*
  - hoffmanni Gabb ... *254*
  - ineziana Conrad ... 14, 17, *254*
    - var. sespeensis Arnold ... 12, 13
  - jewetti Carpenter ... 26, *254*
  - ocoyana Conrad ... 148, *254*
  - pachecoensis Stanton ... *254*
  - uvasana Conrad ... 11, *254*
  - variata Conrad ... 147, 148, *254*
    - sp ... 24

U.

- Union Consolidated Oil Co., wells of ... 33, 54
- Union Oil Co., tanks and pipe lines of ... 134–135, 198

Page.
Union Oil Co., wells of 39, 79, 116, 117, 123, 124
wells of, oil of, analyses of 209, 212
rocks near 116
Upper Ojai Valley, oil wells in 40, 42
oil wells in, location of, map showing 41
rocks in 29
view of 46

V.

Vaqueros formation, age of 12
bitumen in 94
character of 12–13
distribution of 13–17, 37, 62–63, 64, 66, 78, 81–86, 91–93, 97
fossils in 12–13, 14, 17
Modelo formation and, relations of 13, 19–20
oil in 34, 61, 68, 88, 89, 93, 95, 98
overturn of, view of 90
Sespe red beds and, relations of 11
Venericardia planicosta Lamarck 11, 222
ventricosa Gould 153
Ventura, fossils from near 27
Venus pertenuis Gabb 147
temblorensis Anderson 232

W.

Watts, W. L., analyses of 216–217
fossils collected by 24, 26, 152
reports of, on California oils 139, 141, 158
reports of, on Los Angeles district 158–159
West Lake Oil Co., well of, oil of, analysis of 210, 211, 213
West Virginia, oil of, composition of 204
Westlake-Rommell Oil Co., well of, oil of, analysis of 209, 211, 212
Western avenue and Temple road, Los Angeles, area one-fourth mile from, wells of, geology of 181
vicinity of, oil wells in, geology of 178–180
records of 179–180
Western field, development of 159
Western field, geology of 173–184
location of 172
oil wells of 174–184
oil of, analyses of 210, 211, 213
records of 177–180, 184
section in, figure showing 178, 181
structure in 184–186
subdivisions of 174–175
topography of 172
Wheeler Canyon, oil wells in 4, 42, 45–46, 49
oil wells in, oil of, analyses of 209, 211, 212
Whidden-Double Oil Co., oil wells of 40–41
oil wells of, oil of, analysis of 209, 211, 212
Whitney, J. D., explorations by 138, 140
on brea deposits 140–141
Whittier field, gas well in 109
geology of 104–105, 110–112
location of 110
oil wells in 111–115, 133
oil of, analysis of 210, 215
view of 112
pumping plant in, view of 120
structure of 112–115
tankage in 134
Whittier-Fillmore Oil Co., well of, oil of, analysis of 210, 211, 213
Wiley Canyon, fossils from 17
oil wells in 4, 96
oil of, analyses of 210, 211, 213
prospecting in 4
rocks in 15–16, 78, 92

Y.

Yoldia arata Whiteaves 11
cooperi Gabb 28
nasuta Gabb 11
scissurata Dall 24
sp 27, 147

Z.

Zenith Co., oil wells of 98

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[Bulletin No. 309.]

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OF
PRIMARY TRIANGULATION AND PRIMARY TRAVERSE

FISCAL YEAR 1905-6

BY
SAMUEL S. GANNETT

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CONTENTS.

Page.

Summary 1

Eastern division of topography 2

- Alabama 2
  - Primary traverse 2
    - Shelby County 2
      - Coalville quadrangle 2
    - Chambers and Lee counties 3
      - Opelika quadrangle 3
- Alabama-Georgia 5
  - Primary traverse 5
    - Russell County, Ala.; Chattahoochee and Muscogee counties, Ga. 5
      - Columbus quadrangle 5
- Arkansas 6
  - Primary traverse 6
    - Crawford, Franklin, Logan, Scott, and Sebastian counties 6
      - Fort Smith quadrangle 6
- Illinois 10
  - Primary traverse 10
    - Madison and Clinton counties 10
      - Breese quadrangle 10
    - Menard and Sangamon counties 12
      - Tallula quadrangle 12
    - Lake County 13
      - Waukegan quadrangle 13
    - Dupage County 15
      - Wheaton quadrangle 15
- Indiana-Kentucky 17
  - Primary traverse 17
    - Clark, Floyd, and Harrison counties, Ind.; Bullitt, Jefferson, and Oldham counties, Ky 17
      - Louisville, New Albany, Prospect, and Riverview quadrangles 17
- Kentucky 24
  - Primary traverse 24
    - Caldwell, Crittenden, Hopkins, and Webster counties 24
      - Clay quadrangle 24
    - Jefferson County 26
      - Louisville city survey 26
    - Russell and Wayne counties 33
      - Monticello quadrangle 33
    - Franklin and Owen counties 35
      - Sadieville quadrangle 35
    - Anderson, Jefferson, Shelby, and Spencer counties 35
      - Shelbyville and Taylorsville quadrangles 35

Eastern division of topography—Continued. Page

- Louisiana 39
  - Primary traverse 39
    - Ascension, East Baton Rouge, and Iberville parishes 39
      - Baton Rouge quadrangle 39
    - Ascension, Assumption, Iberville, and West Baton Rouge parishes 40
      - Grossetete and Whitecastle quadrangles 40
    - Bossier, Caddo, and De Soto parishes 44
      - Mansfield and Shreveport quadrangles 44
- Michigan 46
  - Primary traverse 46
    - Livingston County 46
      - Howell quadrangle 46
    - Lapeer, Macomb, and Oakland counties 46
      - Leonard quadrangle 46
    - Livingston and Oakland counties 48
      - Milford quadrangle 48
    - Oakland County 48
      - Pontiac quadrangle 48
    - Macomb and Oakland counties 49
      - Rochester quadrangle 49
- Mississippi 50
  - Primary traverse 50
    - Copiah, Hinds, Madison, Rankin, Simpson, and Warren counties 50
      - Brandon, Edwards, Florence, Jackson, Raymond, Terry, and Vicksburg quadrangles 50
- Missouri 58
  - Primary traverse 58
    - Knox, Macon, Monroe, Randolph, and Shelby counties 58
      - Atlanta, Macon, Shelbina, and Shelbyville quadrangles 58
- North Carolina 63
  - Primary traverse 63
    - Sampson County 63
      - Salemburg quadrangle 63
- North Carolina-South Carolina 64
  - Primary traverse 64
    - Cleveland and Gaston counties, N. C.; Cherokee and York counties, S. C 64
      - Belmont, Gaffney, Kings Mountain, and Shelby quadrangles 64
- Ohio 69
  - Primary traverse 69
    - Coshocton, Defiance, Fairfield, Fulton, Guernsey, Henry, Licking, Lucas, Morgan, Muskingum, Noble, Paulding, Perry, Williams, and Wood counties 69
      - Bryan, Butler, Caldwell, Cambridge, Conesville, Continental, Coshocton, Cumberland, Defiance, Deshler, Edon, Frazeysburg, Granville, Logan, McClure, Montpelier, Newark, New Comerstown, New Lexington, Ottawa, Paulding, Philo, Stryker, Sugargrove, Swanton, Thornville, Thurston, Wauseon, and Zanesville quadrangles 69
- Pennsylvania-New York 90
  - Triangulation stations 90
    - Warren County, Pa.; Chautauqua County, N. Y 90
      - Warren and Youngsville quadrangles 90
        - Busti, Chautauqua County, N. Y 91

Eastern division of topography—Continued. Page.

Pennsylvania-New York—Continued.

Triangulation stations—Continued.

Warren County, Pa.; Chautauqua County, N. Y.—Continued.

Warren and Youngsville quadrangle—Continued.

Meas, Chautauqua County, N. Y 91
Peterson, Chautauqua County, N. Y 91
Bull, Warren County, Pa 92
Clarendon, Warren County, Pa 92
Crippen, Warren County, Pa 92
Nelson, Warren County, Pa 93
Quaker Hill, Warren County, Pa 93
Wilcox, Warren County, Pa 93
Yankee Bush, Warren County, Pa 94
Pennsylvania 94
Primary traverse 94
Dauphin, Lebanon, and York counties 94
Middletown quadrangle 94
Berks and Lancaster counties 96
New Holland quadrangle 96
Tennessee 98
Primary traverse 98
Cannon and Rutherford counties 98
Woodbury quadrangle 98
Virginia 100
Triangulation stations 100
Floyd and Patrick counties 100
Floyd and Stuart quadrangles 100
Buffalo, Floyd County 100
Haycock, Floyd County 100
Stocker, Floyd County 100
Bull, Patrick County 101
Carter, Patrick County 101
Hylton, Patrick County 101
Noel, Patrick County 102
Stuart Methodist Episcopal Church spire, Patrick County. 102
Turner, Patrick County 102
Alleghany, Bath, Bedford, Botetourt, Craig, and Rockbridge counties 103
Buchanan and Fincastle quadrangles 103
Rich Patch, Alleghany and Botetourt counties 103
Potts, Alleghany and Craig counties 103
Bald Knob, Bath County 104
Caldwell, Botetourt County 104
Sugar Loaf, Botetourt County 104
Flat Top, Botetourt and Bedford counties 105
Short Hill, Rockbridge county 105
West Virginia 106
Triangulation stations 106
Braxton, Calhoun, Clay, Kanawha, Roane, and Wirt counties 106
Arnoldsburg, Flatwood, Little Otter, Minnora, Spencer, and Walton quadrangles 106
Coon, Braxton County 106

Eastern division of topography—Continued. Page.
West Virginia—Continued.
Triangulation stations—Continued.
Braxton, Calhoun, Clay, Kanawha, Roane, and Wirt counties—Con.
Arnoldsburg, Flatwood, Little Otter, Minnora, Spencer, and Walton quadrangles—Continued.

Frame, Braxton County 106
Gip, Braxton County 107
Green, Braxton and Nicholas counties 107
High, Braxton County 107
Sugar, Braxton County 108
Desert, Calhoun County 108
Millstone, Calhoun County 109
Mule, Calhoun County 109
Kite, Calhoun County 109
Lukens, Calhoun-Wirt county line 110
Rattlesnake, Calhoun County 110
Harrison, Clay County 110
Pilot, Clay County 111
Gunstock, Kanawha County 111
Ball, Roane County 112
Campbell, Roane County 112
Countsville, Roane County 112
Craig, Roane County 113
Nichols, Roane County 113
Poplar, Roane County 113
Spencer, Roane County 114
Staats, Roane County 114
Weedy, Roane County 115
Ruble, Wirt County 115
Wood, Wirt, Jackson, and Roane counties 115
Wisconsin 116
Primary traverse 116
Dane County 116
Cross Plains quadrangle 116
Rock and Walworth counties 117
Delavan, Janesville, and Shopiere quadrangles 117
Dodge, Milwaukee, Ozaukee, and Washington counties 119
Clyman, Hartford, Port Washington, Waukesha, and Westbend quadrangles 119
Western division of topography 122
California 122
Triangulation stations 122
Colusa and Yolo counties 122
Copay, Colusa, Dunnigan, Rumsey, and Woodland quadrangles 122
Arbuckle, Colusa County 122
Ash, Colusa County 122
Barn, Colusa County 123
College City, Colusa County 123
Colusa, Colusa County 123
Foothill, Colusa County 124
Franklin, Colusa County 124
Johns, Colusa County 125

Western division of topography—Continued. Page.
California—Continued.
Triangulation stations—Continued.
Colusa and Yolo counties—Continued.
Copay, Colusa, Dunnigan, Rumsey, and Woodland quadrangles—Continued.

Smokestack, Colusa County.......... 125
Stovall, Colusa County.......... 125
Webster, Colusa County.......... 126
Williams, Colusa County.......... 126
Blacks, Yolo County.......... 126
Blodgett, Yolo County.......... 127
Brickhouse, Yolo County.......... 127
Corbin, Yolo County.......... 127
Curtis, Yolo County.......... 128
Davisville, Yolo County.......... 128
Dunnigan, Yolo County.......... 128
Esparta, Yolo County.......... 129
Fairview, Yolo County.......... 129
Gallup, Yolo County.......... 129
Green, Yolo County.......... 130
Hines, Yolo County.......... 130
Mesa, Yolo County.......... 130
Monticello, Yolo County.......... 131
Mumma, Yolo County.......... 131
Roth, Yolo County.......... 132
Scott, Yolo County.......... 132
Stevens, Yolo County.......... 132
Windmill, Yolo County.......... 133
Winters, Yolo County.......... 133
Winters School, Yolo County.......... 134
Woodland city hall, Yolo County.......... 134
Woodland high school, Yolo County.......... 134
Yolo, Yolo County 134
Yolo northwest base, Yolo County.......... 135
Yolo southeast base, Yolo County.......... 135
Mariposa and Tuolumne counties.......... 136
Yosemite Special quadrangle.......... 136
Clouds Rest, Mariposa county.......... 136
Devil Peak, Mariposa County.......... 137
Dewey, Mariposa County.......... 137
Eagle, Mariposa County.......... 137
El Capitan, Mariposa County.......... 138
Flat, Mariposa County.......... 138
Glacier Point, Mariposa County.......... 138
Pilot Peak, Mariposa and Tuolumne counties.......... 139
Sentinel Dome, Mariposa County.......... 139
Starr King, Mariposa County.......... 140
Valley, Mariposa County.......... 140
Yosemite Point, Mariposa County.......... 140
California-Nevada.......... 141
Triangulation stations.......... 141
Esmeralda and Nye counties, Nev.; Inyo County, Cal.......... 141
Amargosa region.......... 141

Western division of topography—Continued. Page.
  California-Nevada—Continued.
    Triangulation stations—Continued.
      Esmeralda and Nye counties, Nev.; Inyo County, Cal.—Continued.
        Amargosa region—Continued.
          Boundary, Inyo County, Cal 142
          Death, Inyo County, Cal 142
          Furnace, Inyo County, Cal 143
          Grape, Inyo County, Cal 143
          Telescope Peak, Inyo County, Cal 144
          Tin, Inyo County, Cal 144
          Andesite, Esmeralda County, Nev 144
          Columbia, Esmeralda County, Nev 145
          Gold Mountain, Esmeralda County, Nev 145
          Lone Mountain, Esmeralda County, Nev 145
          Montezuma, Esmeralda County, Nev 146
          Timpahute, Lincoln County, Nev 146
          Bare, Nye County, Nev 147
          Beatty, Nye County, Nev 147
          Belted Peak, Nye County, Nev 147
          Busch, Nye County, Nev 148
          Cactus Peak, Nye County, Nev 148
          Cane, Nye County, Nev 149
          Chalk Mountain, Nye County, Nev 149
          Diamond, Nye County, Nev 149
          Forty (Shoshone Mountain), Nye County, Nev 150
          Jumbo, Nye County, Nev 150
          Kawich, Nye County, Nev 150
          Mal, Nye County, Nev 151
          Mesa (Pahute), Nye County, Nev 151
          Quartzite, Nye County, Nev 151
          Reveille, Nye County, Nev 152
          Sheet Line, Nye County, Nev 152
          Stonewall, Nye County, Nev 153
          Timber, Nye County, Nev 153
          Tolicha, Nye County, Nev 153
          Wheelbarrow Peak, Nye County, Nev 154
          White Pine, Nye County, Nev 154
          Yellow, Nye County, Nev 155
          Tertiary points located by intersections, Nevada 155
      Fresno, Inyo, Mono, Tulare, and Tuolumne counties, Cal.; Esmeralda and Nye counties, Nev 155
        High Sierra region, California; Goldfield region, Nevada 155
          Goddard, Fresno County, Cal 156
          Hilgard, Fresno County, Cal 156
          Kaiser, Fresno County, Cal 156
          Humphreys, Fresno and Inyo counties, Cal 157
          Red Slate, Fresno and Mono counties, Cal 157
          Split Mountain, Fresno and Inyo counties, Cal 158
          Silver, Fresno County, Cal 158
          Big Pine, Inyo County, Cal 159
          Bishop, Inyo County, Cal 159
          Black Mountain, Inyo County, Cal 159
          Crater, Inyo county, Cal 160

Western division of topography—Continued. Page.

California-Nevada—Continued.

Triangulation stations—Continued.

Fresno, Inyo, Mono, Tulare, and Tuolumne counties, Cal.; Esmeralda and Nye counties, Nev.—Continued.

High Sierra region, California; Goldfield region, Nevada—Con.

Darwin, Inyo County, Cal.................................... 160
Double, Inyo County, Cal.................................... 160
Independence, Inyo County, Cal.............................. 160
Keynot, Inyo County, Cal.................................... 161
Morgan, Inyo County, Cal.................................... 161
Olancha, Inyo and Tulare counties, Cal...................... 161
Palisade, Fresno and Inyo counties, Cal..................... 162
Pinchot, Fresno and Inyo counties, Cal...................... 162
Piper, Inyo County, Cal..................................... 163
Round, Inyo County, Cal..................................... 163
Sheep, Inyo County, Cal..................................... 163
Tom, Inyo County, Cal....................................... 164
Waucoba, Inyo County, Cal................................... 164
Three Sisters, Fresno County, Cal........................... 164
White Top, Inyo County, Cal................................. 165
Whitney, Tulare and Inyo counties, Cal...................... 165
Williamson, Tulare and Inyo counties, Cal................... 166
Baldy, Mono County, Cal..................................... 166
Castle Peak, Mono County, Cal............................... 167
Horse, Mono County, Cal..................................... 167
Heckla, Mono County, Cal.................................... 167
Lyell, Mono County, Cal..................................... 168
Mono, Mono County, Cal...................................... 168
Monument, Mono County, Cal.................................. 168
White Mountain North, Mono County, Cal...................... 169
White Mountain South, Mono County, Cal...................... 169
Big Meadows, Tulare County, Cal............................. 170
Brewer, Tulare County, Cal.................................. 170
Florence, Tulare County, Cal................................ 170
Kaweah Mountain, Tulare County, Cal......................... 171
Kern, Tulare County, Cal.................................... 171
Mahogany, Tulare County, Cal................................ 171
Trail, Tulare County, Cal................................... 172
Conness, Tuolumne County, Cal............................... 172
California-Nevada boundary post triangulation station 75. 173
California-Nevada boundary post triangulation station 74. 173
Blue Dick, Esmeralda County, Nev............................ 173
Gold Mountain, Esmeralda County, Nev........................ 173
Lone Mountain, Esmeralda County, Nev........................ 174
Magruder, Esmeralda County, Nev............................. 174
Montezuma, Esmeralda County, Nev............................ 175
Stonewall, Nye County, Nev.................................. 175
California.. 175
Primary traverse.. 175
Colusa, Sacramento, and Molo counties....................... 175
Special sheets Nos. 19, 20, 21, and 28...................... 175

Western division of topography—Continued.

Page.

Montana........ 178

Triangulation stations........ 178

Fergus County........ 178

Moccasin Mountain, Maiden, and Kendall quadrangles........ 178

Big Snowy........ 178

Dogmelle........ 178

Fence Corner........ 179

Fergus........ 179

Fox Pass........ 179

Judith........ 180

North Moccasin........ 180

Pyramid........ 181

Skaggs........ 181

South Moccasin........ 181

Tufted Pine........ 182

North Moccasin Mountains, middle peak........ 182

Eastern of two trees........ 182

Nipple-shaped hill........ 183

Lewistown high school (center of building)........ 183

South Moccasin Mountains (northwest peak)........ 183

Judith Mountains (middle west peak)........ 183

Porphyry Peak........ 183

Windmill........ 183

Black Butte........ 183

Cone Butte........ 183

Lindsy's ranch house........ 184

Small tree on summit of hill........ 184

Deerlodge, Granite, Powell, and Ravalli counties........ 184

Philipsburg and Sapphire quadrangles........ 184

Bench-mark post 5124, Deerlodge County........ 184

Howe, Deerlodge County........ 184

Short Peak, Deerlodge County........ 185

Washoe smelter smokestack, Deerlodge county........ 185

Warm Springs, insane asylum, Deerlodge County........ 185

West Mound, Deerlodge County........ 185

Bare Hill, Granite County........ 186

Black Pine, Granite County........ 186

Chicago, Granite County........ 186

Congdon Peak, Granite and Ravalli counties........ 187

Dome-shaped mountain, Granite County........ 187

Emerine, Granite County........ 187

Fish Peak, Granite County........ 188

Fourth prominent peak southwest of Mount Warren, Granite County........ 188

Fox Peak, Granite and Ravalli counties........ 188

Haggin, Granite County........ 188

Harvey, Granite County........ 189

Moore, Granite County........ 189

New Chicago, Granite County........ 190

Peak 2 miles east of Quigg, Granite County........ 190

Peak east of Haggin and 6 miles southwest of Anaconda, Granite County........ 190

Point Lookout, Granite County........ 190

Western division of topography—Continued. Page.

Montana—Continued.

Triangulation stations—Continued.

Deerlodge, Granite, Powell, and Ravalli counties—Continued.

Philipsburg and Sapphire quadrangles—Continued.

Prairie, Granite County 191
Princeton, Granite County 191
Prominent bare hill, Granite County 191
Quigg, Granite County 192
Red Lion, Granite County 192
Sugar Loaf, Granite County 193
Summit of high, sparsely timbered hill, Granite County 193
Third prominent peak southwest of Mount Warren, Granite County 193
Warren, Granite County 193
Wilma post-office, Granite County 194
Pikes Peak, Powell County 194
Powell, Powell County 194
Deer Mountain, Ravalli County 194
Kent, Ravalli County 195
Palisade, Ravalli County 195
67, Ravalli County 196
68, Ravalli County 196
Willow, Ravalli County 196
New Mexico 197
Triangulation stations 197
Bernalillo, Socorro, and Valencia counties 197
Albuquerque, university flag pole, Bernalillo County 197
Vulcan, Bernalillo County 197
Campana, Socorro County 198
Canas, Socorro County 198
Chupadera, Socorro County 199
Isleta, Socorro County 199
North Base, Socorro County 199
Polvadera, Socorro County 200
Sanders, Socorro County 200
Socorro Peak, Socorro County 201
South base, Socorro County 201
Turututu, Socorro County 202
Lucero, Valencia County 202
Lunas, Valencia County 202
Tome, Valencia County 203
Secondary triangulation stations 203
Albuquerque, Bernalillo County 203
Isleta, Bernalillo County 203
Belen, Valencia County 203
La Joya, Valencia County 204
Las Lunas, Valencia County 204
Rio Puerco bridge, Valencia County 204
San Acacia mesa, Valencia and Socorro counties 204
Alamillo, Socorro County 204
Lemitar, Socorro County 204
Luis Lopez, Socorro County 204
Magdalena, Socorro County 204

Western division of topography—Continued. Page.
New Mexico—Continued.
Secondary triangulation stations—Continued.
Polvadera, Socorro County.................................... 204
San Antonio, Socorro County.................................... 204
Socorro, Socorro County.................................... 205
Water Canyon (branch railroad), Socorro County........ 205
Oklahoma.. 205
Triangulation stations.................................... 205
Lincoln, Logan, Oklahoma, and Payne counties................ 205
Agra, Chandler, Edmond, Guthrie, Mallon, Merrick, Quay, Ripley, and Sac-Fox quadrangles.......................... 205
Cox, Number 9 County.................................... 205
Agra, Lincoln County.................................... 205
Agra oil tower, Lincoln County.......................... 206
Air, Lincoln County.................................... 206
Avery, Lincoln County.................................... 206
Buck, Lincoln county.................................... 207
Chandler standpipe, Lincoln County...................... 207
Girdle, Lincoln County.................................... 207
Harger, Lincoln County.................................... 208
Mesecher, Lincoln County.................................... 208
Phee, Lincoln County.................................... 208
Sac-Fox agency water tank, Lincoln County............ 209
Stuart, Lincoln County.................................... 209
Tryon, Lincoln County.................................... 209
Flinn, Logan County.................................... 209
Guthrie standpipe, Logan County...................... 210
Langston, Logan County.................................... 210
Reece, Logan County.................................... 211
Short, Logan County.................................... 211
Strong, Logan County.................................... 211
Wallace, Logan County.................................... 212
Wingard, Logan County.................................... 212
Edmond, Oklahoma County.................................... 212
Cordis, Payne County.................................... 213
Cushing, Payne County.................................... 213
Cushing oil tower, Payne County.......................... 214
Cushing, Christian Church spire, Payne County.......... 214
Indian, Payne County.................................... 214
Mound, Payne County.................................... 214
Paradise, Payne County.................................... 215
Perkins, Payne County.................................... 215
Perkins, tallest church spire, Payne County............ 215
Quay, Pawnee County.................................... 216
Primary traverse.................................... 216
Logan County.................................... 216
Guthrie quadrangle.................................... 216
Texas-Louisiana.................................... 217
Primary traverse.................................... 217
Bowie, Cass, Fannin, Gregg, Harrison, Lamar, Marion, Red River, Titus, and Upshur counties, Tex; Caddo Parish, La............ 217
Clarksville, Gilmer, Jefferson, Mount Pleasant, Mount Vernon, Paris, Shawneetown, and Texarkana quadrangles.......... 217

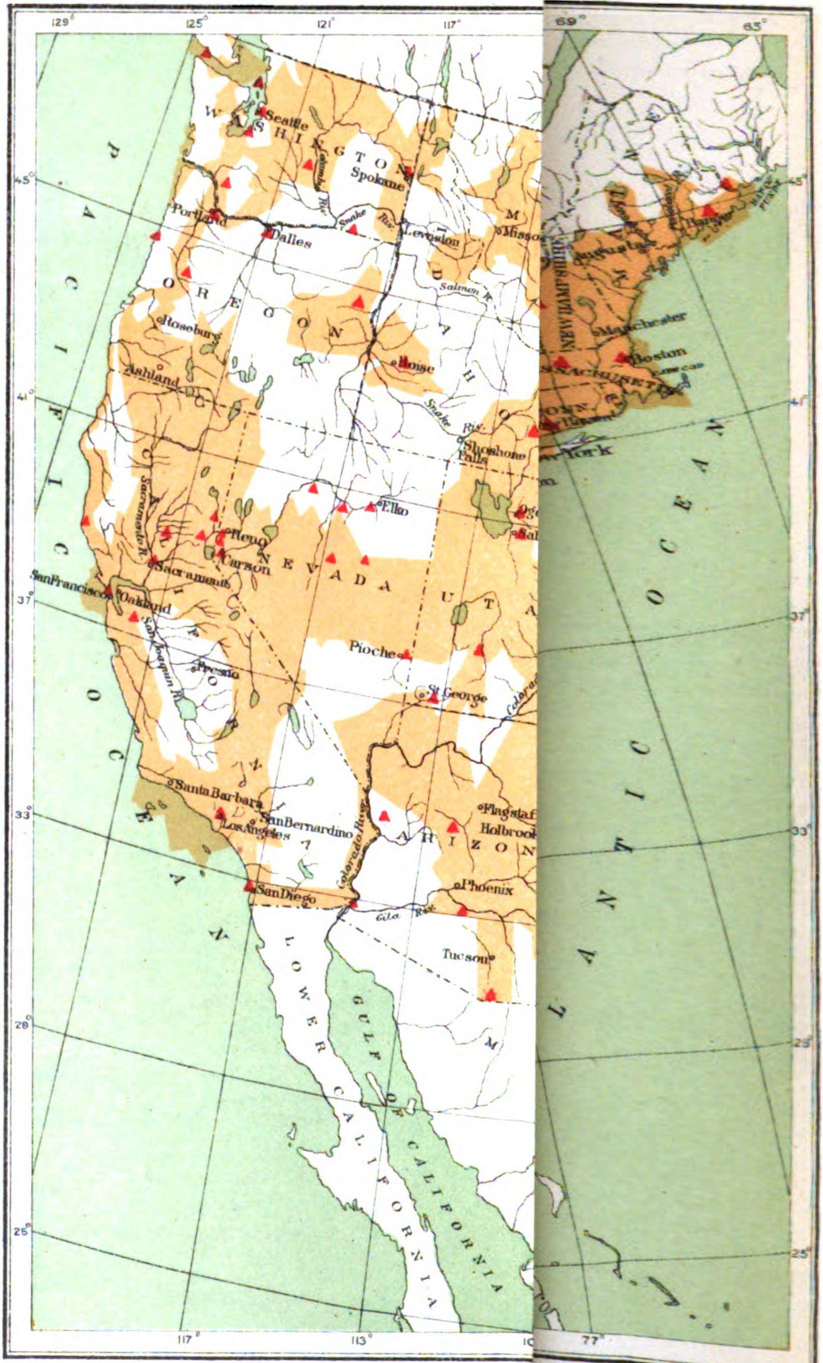
Western division of topography—Continued. Page.
- Utah-Nevada 226
  - Triangulation stations 226
    - Beaver, Iron, and Piute counties, Utah; Lincoln County, Nev.... 226
      - Iron Springs Special quadrangle 226
        - Blue, Beaver County, Utah 226
        - Frisco Peak, Beaver County, Utah 226
        - Granite, Beaver County, Utah 226
        - Hot, Iron County, Utah 227
        - Iron, Iron County, Utah 227
        - Peak, Iron County, Utah 227
        - Springs, Iron County, Utah 228
        - Tushar, Piute County, Utah 228
        - Pioche, Lincoln County, Nev 229
- Wyoming 229
  - Triangulation stations 229
    - Bighorn, Fremont, and Natrona counties 229
      - Alcove, Broken Horn, Lost Cabin, Nowood, Nowater, and Watrous quadrangles 229
        - Deranch, Bighorn County 229
        - Mahogany, Bighorn County 230
        - Copper, Fremont County 230
        - Herder, Fremont County 231
        - Poison, Fremont County 231
        - Round Hill, Fremont County 231
        - Badwater, Natrona County 232
        - Clark, Natrona County 232
        - Cottonwood Pass, Natrona County 233
        - Easy, Natrona County 233
        - Enoch, Natrona County 234
        - Jack Pot, Natrona County 234
        - Reservoir, Natrona County 234

Index 237

ILLUSTRATION.

Page.

Plate I. Map showing condition of astronomic location and primary control to April 30, 1906 1



A. Hoen & Co. Lith. Balto.

MAP SH

Areas tinted are controlled by triangulation or traver

▲ Astronomic station

RESULTS OF PRIMARY TRIANGULATION AND PRIMARY TRAVERSE, FISCAL YEAR 1905-6.

By SAMUEL S. GANNETT.

SUMMARY.

Summary of published results, 1905–6: Triangulation and primary traverse.

Locality.	Triangulation stations.	Traverse stations.
EASTERN DIVISION.		
Alabama	....	94
Alabama-Georgia	....	63
Arkansas	....	117
Illinois	....	161
Indiana-Kentucky	....	163
Kentucky	....	324
Louisiana	....	168
Michigan	....	178
Mississippi	....	198
Missouri	....	137
North Carolina	....	60
North Carolina-South Carolina	....	144
Ohio	....	532
Pennsylvania	10	92
Tennessee	....	61
Virginia	16	....
West Virginia	26	....
Wisconsin	....	174
WESTERN DIVISION.		
California	50	58
California-Nevada	93	....
Montana	65	....
New Mexico	38	....
Oklahoma	33	11
Texas-Louisiana	....	336
Utah-Nevada	9	....
Wyoming	13	....
	353	3,071

EASTERN DIVISION OF TOPOGRAPHY.

H. M. Wilson, *Geographer in charge.*

ALABAMA.

PRIMARY TRAVERSE.

SHELBY COUNTY.

COALVILLE QUADRANGLE.

In June, 1906, C. B. Kendall, field assistant, ran a line of primary traverse across the southern border of this quadrangle from Longview to Teague bridge over Yellow Leaf Creek, connecting with points on the United States standard datum previously located by primary traverse.

Magnetic declination, 2° 51′ 38″ east.

Geographic positions along Louisville and Nashville Railroad near Longview.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Longview, at southwest corner of company's store, iron post stamped "Prim. Trav. Sta. No. 28, 1906"	33	11	56.9	86	46	45.
Longview, public-road crossing 0.5 mile north of, center of track	33	12	21.0	86	46	39.
Saginaw station, public-road crossing 0.5 mile south of, center of trestle	33	12	47.3	86	47	22.6
Saginaw station, public-road crossing	33	13	01.9	86	47	57.5

Geographic positions along highways.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Saginaw, mail box at four corners 0.5 mile northwest of	33	13	14.3	86	48	20.7
Saginaw, about 1 mile north of, second-class road fork to south	33	13	29.8	86	47	43.1
Forks	33	14	52.1	86	46	41.7
Pine stump at east side of road at top of small ridge	33	15	41.6	86	45	31.3
Second-class forks to north at bend of main road to east	33	16	04.7	86	44	46.0
Forks at rail fence, 150 feet west of bridge over small stream, public road to west, second-class road to north uphill	33	16	10.1	86	44	04.3
Second-class north-south road	33	16	02.4	86	43	31.8
Forks of road 300 feet east of house, roads east to northeast	33	16	03.4	86	42	51.3
Four corners at vacant dwelling, public road northwest and southeast	33	16	10.2	86	42	28.7
Four corners, public and second-class crossroads	33	16	18.8	85	42	07.3
Section-line crossing (")	33	16	28.5	86	41	52.2
Yellow Leaf Creek, center of bridge over small branch of	33	16	46.1	86	41	30.2
Forks of road 0.75 mile southwest of box and 20 feet north of signboard "Calera 14 miles"	33	17	00.3	86	41	12.8
Public roads northeast, north, and southwest	33	17	02.9	86	41	03.0
Calvary Baptist Church, forks 0.5 mile east of, public road to south	33	17	02.9	86	40	30.0
Section corner (number not obtained)	33	17	00.7	86	40	29.1

Geographic positions along highways—Continued.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
T. 20, R. 1 W., northeast corner sec. 20	33	17	02.2	86	39	26.4
Ransom station, four corners 150 feet south of cotton gin and 60 feet west of lumber railroad	33	17	05.2	86	39	27.5
Saginaw station, on Saginaw Lumber Co.'s railroad, 250 feet northeast of cotton gin, 200 feet northeast of railroad crossing, 100 feet southeast of dwelling, and about 8 feet south of water oak tree, aluminum tablet in sandstone bowlder, stamped "Prim. Trav. Sta. No. 1, 1906"	33	17	07.8	86	39	26.6
Public-road forks, second-class road to southwest, 10 feet southwest to oak painted "USTP 549.8"	33	17	24.0	86	38	44.2
Public-road forks, 15 feet south to signpost marked "Pelham 11.25 miles"	33	17	29.5	86	37	55.1
Four corners, 300 feet southwest of church, 30 feet east to well, 15 feet southwest to oak	33	17	37.7	86	37	18.1
Forks of road southeast and northeast, stump painted "VA 551" on top of small ridge	33	18	17.5	86	36	53.0
T. 20 S., R. 1 W., sec. 11, center line of, public-road crossing	33	18	16.6	86	36	49.4
Secs. 12 and 13, quarter corner north of southeast corner sec. 12, forks of road south and east	33	18	10.9	86	36	02.1
Forks of road east and west, 20 feet northeast to dead pine snag	33	17	56.8	86	35	30.0
Yellow Leaf Creek, center of bridge over northern fork of	33	17	56.2	86	35	08.8
Public road west, forks of, 1.5 miles south of Teague bridge, second-class road to northwest, 10 feet east to pine, 30 feet west to pine stump	33	17	21.8	86	33	51.3
Four corners, crossroads, 1.5 miles south of Teague bridge, 20 feet west to bunch oak trees and signboard marked "Wilsonville"	33	17	15.2	86	33	25.7
Public-road forks, south and southeast, 50 feet southeast to pine, 40 feet north to oak	33	17	40.2	86	33	21.7
Three corners, 0.5 mile south of Teague bridge, public T road west	33	17	57.0	86	33	23.8
Yellow Leaf Creek, center of Teague bridge over, public roads south and southeast (located in 1904)	33	18	22.9	86	33	06.8

CHAMBERS AND LEE COUNTIES.

OPELIKA QUADRANGLE.

The following geographic positions were determined by primary traverse run by E. L. McNair, topographer, in April, 1905. The line starts at West Point, Ga., and runs northerly and westerly along public roads via Fredonia and White Plains to Penton, thence south via Marcoot to Gold Hill station, on the Central of Georgia Railway. Another line starts at Auburn station, on the Western Railway of Alabama, and runs via highways south to Wrights Corners, thence easterly and northerly to Salem, Ala.

Geographic positions along highways.

Station.	Latitude.			Longitude.		
GEORGIA.	°	′	″	°	′	″
West Point, Atlanta and West Point R. R. station (Ellis, 1902)	32	52	31.8	85	11	01.6
West Point, Atlanta and West Point R. R. bridge over Chattahoochee River, southwest end of, in capstone at north end of shore pier, bronze tablet stamped "Anniston 573 Ft."	32	52	46.4	85	10	50.1
Alabama-Georgia State line crossing of West Point and Fredonia road.	32	54	09.3	85	11	28.7
ALABAMA.						
West Point, 3.5 miles northwest of, 0.12 mile east of house of E. L. Bailey (colored), on north side of road between two oak trees, iron post stamped "Anniston 695 ft. Prim. Trav. Sta. No. 14, 1905"	32	54	46.5	85	12	56.1
Potts (Charles) mail box, T road northwesterly	32	55	08.9	85	13	21.6
Fredonia, 4.75 miles southeast of, forks of road	32	56	30.9	85	14	45.0
Fredonia, 3.5 miles southeast of, forks of road at signboard "West Point 7 miles"	32	57	21.5	85	15	16.2
Fredonia, 1.5 miles southeast of, forks of road	32	58	37.7	85	16	16.5

Geographic positions along highways—Continued.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
ALABAMA—continued.						
Fredonia, 40 feet southwest of, crossroads, iron post stamped "Prim. Trav. Sta. No. 15, 1905"	32	59	21.1	85	17	14.4
Fredonia, 1.25 miles west of, forks of road at signboard	32	59	24.2	85	18	31.0
Fredonia, 2.25 miles northwest of, four corners	33	00	04.8	85	19	10.8
Five Points, 1.75 miles southeast of	33	00	38.2	85	19	44.2
Five Points, 0.5 mile south of, four corners	33	00	47.7	85	20	57.2
Five Points, 1.25 miles southwest of, highway and Central of Georgia Rwy. crossing	33	00	30.8	85	21	50.5
Central of Georgia Rwy. and Settlement road crossing	32	59	35.0	85	22	42.1
White Plains, four corners at McCarley's store	32	59	21.8	85	24	10.8
Chapel Hill, house of W. L. Wilson, center of road opposite	32	59	37.3	85	25	50.9
Jenkins (W. T.) house, center of road opposite west end of	33	00	07.7	85	27	02.1
Penton, four corners, 14 feet from corner of Storey's warehouse and 49 feet from post-office, iron post stamped "Prim. Trav. Sta. No. 16, 1905"	33	00	19.2	85	28	00.5
Penton, 1.75 miles south of, house of W. Lowe, jr., center of road opposite	32	58	53.8	85	28	12.2
Penton, 3.25 miles south of, house of J. B. Lashley, center of road opposite	32	57	31.4	85	28	03.2
Marcoot post-office, road corners 200 feet west of	32	57	21.8	85	29	06.7
Marcoot post-office, 1.5 miles south of, on top of ridge, center of road opposite W. T. Weldon's house	32	56	12.5	85	29	30.6
Marcoot, 3.25 miles south of, forks of road; roads north, south, and east	32	54	44.8	85	29	23.0
Lafayette, 5 miles west of, near house of S. M. Abernathy, four corners	32	53	54.4	85	29	13.9
Stills (H.) residence, roads north, south, and west	32	53	23.4	85	28	52.2
Jones store, 0.75 mile northeast of, four corners	32	52	03.2	85	28	22.9
T. 22 N., R. 26 E., in sec. 30, 3.5 feet from southeast corner of S. W. Jones's store, iron post stamped "Prim. Trav. Sta. No. 17, 1905"	32	51	43.3	85	29	01.6
Jones store, 1.5 miles southwest of, forks of roads	32	50	53.5	85	30	09.2
Lafayette and Camp Hill road, house of W. F. Royal, 0.25 mile southeast of, four corners	32	50	12.7	85	30	27.6
Forks of road	32	48	45.0	85	30	47.3
House of A. B. McKinney, 250 feet south of, forks of road	32	48	05.4	85	30	13.2
Forks of road	32	46	48.8	85	30	06.6
House of Alfred Johnson, 0.33 mile south of, four corners	32	46	20.1	85	30	08.4
Forks of road	32	45	23.2	85	30	08.4
Forks of road, east, west, and north	32	44	19.5	85	30	00.9
Gold Hill station (Hawkins, 1901)	32	43	25.8	85	30	29.2

Geographic positions south and east of Auburn, Ala.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Auburn station (Hawkins, 1901), road east of	32	36	37.1	85	28	48.0
Auburn station, 0.9 mile south of, roads east, west, and south	32	35	55.9	85	28	42.7
Auburn station, 2.25 miles south of, Society Hill road, 10 feet southeast of, iron post stamped "Prim. Trav. Sta. No. 18, 1905"	32	34	52.4	85	28	10.8
T road east	32	33	55.4	85	28	31.2
Chewacla Creek, center of covered bridge over	32	32	53.0	85	28	50.0
Wright (L. A.) house, four corners near	32	32	00.7	85	28	13.0
Wright's corners, 1.75 miles east of, forks of road	32	31	55.3	85	26	28.3
Roads north, south, and east	32	32	26.4	85	25	44.8
Mitchell's store, four corners	32	32	20.1	85	24	49.5
Chafin (H. C.) residence, center of road opposite	32	32	11.8	85	23	49.5
Four corners	32	32	16.9	85	22	19.8
Providence Church, road corners 0.5 mile south of	32	32	40.1	85	20	28.4
Forks of road	32	31	45.9	85	20	18.3
T road south	32	31	11.9	85	18	51.6
Prince (George) residence, four corners	32	30	37.2	85	16	19.9
Meadows, four corners	32	31	15.0	85	15	16.7
Salem station, 4.25 miles south of, 200 feet south of Butler house, 10 feet west of center of road, iron post stamped "Prim. Trav. Sta. No. 19, 1905, 526 ft."	32	32	08.6	85	15	23.9
Salem, 2.25 miles south of, forks of road	82	33	48.5	85	15	14.9
Salem, 0.75 mile south of, forks of road	32	35	07.0	85	14	32.8
Salem station (Ellis, 1902)	32	35	49.6	85	14	18.8
Salem station, 660 feet west of, 32 feet north of center of track of Central of Georgia Rwy., iron post stamped "Prim. Trav. Sta. No. 20, 1905, 686 ft."	32	35	51.3	85	14	26.1

ALABAMA-GEORGIA.

PRIMARY TRAVERSE.

RUSSELL COUNTY, ALA.; CHATTAHOOCHEE AND MUSCOGEE COUNTIES, GA.

COLUMBUS QUADRANGLE.

The following geographic positions were determined by C. B. Kendall, field assistant, in 1906. The line begins at Columbus, located by primary traverse in 1902 by J. R. Ellis, crosses Chattahoochee River to Girard, Ala., follows the Central of Georgia Railway to Fort Mitchell, thence along highways along the west, south, and east borders, tying to primary traverse station No. 3, established at Upatoie in 1905 by E. L. McNair, topographer.

Geographic positions along Central of Georgia Railway between Columbus, Ga., and Fort Mitchell, Ala.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
GEORGIA.						
Columbus, First avenue crossing	32	28	39.1	84	59	29.8
Columbus, in west wall at north side of west entrance to post-office building, aluminum tablet stamped "Prim. Trav. Sta. No. 1, 1906," elevation 251 feet	32	28	06.4	84	59	29.6
Chattahoochee River, center of Central of Georgia Rwy. bridge over	32	27	43.8	84	59	50.9
ALABAMA.						
Girard station, 75 feet north of, road crossing	32	27	39.8	84	59	57.5
Milepost 2, road crossing 60 feet south of	32	27	15.8	84	59	50.3
Siding, road crossing 50 feet south of	32	26	04.6	84	59	33.5
Station notice post, second-class road crossing 50 feet north of	32	24	15.6	85	00	28.3
Brickyard station, east rail of main track at road crossing	32	23	49.8	85	00	33.3
Second-class road crossing	32	22	46.5	85	00	19.1
Flag station, 500 feet south of, road crossing near water mill	32	22	04.7	85	00	32.8
Second-class road crossing	32	21	06.7	85	00	49.4
Fort Mitchell station, road crossing	32	20	33.9	85	01	12.2
Fort Mitchell station, 100 feet south of, at northeast corner of store of G. L. Salas, iron post stamped "Prim. Trav. Sta. No. 2, Ala., 1906".	32	20	33.0	85	01	12.5
Big Uchee Creek, west end of iron bridge over, forks of road southeast and southwest	32	18	57.6	85	01	02.6
Small stream crossing, second-class road west	32	18	18.6	85	00	37.2
Cotton gin, second-class road	32	17	39.9	85	00	27.4
Osweechee Church, three corners, T road east, 30 feet to tall pine	32	16	36.4	85	00	11.8
Osweechee Church, 0.5 mile south of, at southeast corner, at junction of north and south river road and road east to Hatchers Landing, iron post stamped "Prim. Trav. Sta. No. 3, 1906, Ga."	32	16	14.6	85	00	02.5
Three corners, T road north, 20 feet east to pine	32	16	09.8	84	59	26.5
T. 15, R. 30, corner sec. 19, pine log planted in small marsh 224 feet east of three corners, T road to west	32	16	10.9	84	58	00.5
Four corners, 40 feet southeast to pine, 50 feet north to pine	32	15	56.8	84	58	03.6
Triangle at road forks, southeast and southwest	32	15	09.9	84	56	53.2
Forks of road west, southwest, and northwest, 10 feet south to willow.	32	14	56.1	84	56	30.7
Forks of road northeast, second-class road southeast leading to Fitzsimmons Ford	32	15	03.0	84	55	43.4
Chattahoochee River, Fitzsimmons Landing, on top of west bank at edge of field, 125 feet west of landing proper	32	14	51.4	84	55	30.9
Alabama-Georgia State line, center of Chattahoochee River, about 800 feet south of Fitzsimmons Landing	32	14	42.8	84	55	23.5
GEORGIA.						
Forks of road between two small houses, roads west and southwest, 40 feet east to small house, 40 feet south to house	32	14	19.8	84	54	19.8
Forks of road east and southeast, 100 feet east of top of ridge	32	14	15.1	84	53	56.8
St. Mark's Church (colored) at junction of Columbus-Florence and Florence-Cusseta roads, at southwest corner of church, iron post stamped "Prim. Trav. Sta. No. 2, Ga. 1906"	32	14	40.6	84	52	52.8
Forks of road west and southwest, 10 feet north to cedar, 50 feet southeast to pine	32	14	50.9	84	51	11.2
Jamestown, forks of road north and northeast, 600 feet north of, 20 feet east to rail fence, 40 feet north to persimmon	32	15	53.8	84	50	45.6

Geographic positions along Central of Georgia Railway between Columbus, Ga., and Fort Mitchell, Ala.—Continued.

Station.	Latitude.			Longitude.		
GEORGIA—continued.	°	′	″	°	′	″
Cemetery, forks of road east and southeast	32	16	00.3	84	50	17.5
Stephens Creek, center of bridge over	32	15	59.3	84	49	37.0
Three corners, T road southwest	32	16	11.3	84	49	05.4
Forks of road northeast and southeast, 40 feet north to double oak, 30 feet south to clump of plum bushes	32	16	25.5	84	48	06.9
Cusseta, 3 miles south of, forks of road south and southeast	32	16	44.4	84	47	47.6
Cusseta, 3 miles south of, in angle at forks of road Cusseta-Lonvale, Cusseta-Jamestown, iron post stamped "Prim. Trav. Sta. No. 3, Ga. 1906"	32	16	44.1	84	47	47.8
Forks of road northwest and north	32	17	26.4	84	47	28.1
Cusseta, 1 mile southwest of, forks of road north and northeast, 10 feet north to pine	32	18	12.1	84	47	16.8
Cusseta, forks of road at west edge of, 40 feet west to sign "Jamestown 6 mi.," 60 feet east to large oak stump	32	18	28.2	84	47	04.4
Cusseta, 0.75 mile northwest of, overhead road crossing Seaboard Air Line Rwy	32	18	30.7	84	47	18.6
Cusseta, 1.5 miles northwest of, road crossing Seaboard Air Line Rwy.	32	18	46.8	84	47	38.7
Milepost C 16; road crossing 300 feet south of	32	20	09.6	84	47	35.2
Ochilles Creek, south end of bridge over	32	20	42.8	84	47	09.2
Halleck station, road crossing 500 feet east of water tank	32	20	53.7	84	47	02.1
Old store, four corners, roads north and south and west and east, 50 feet southwest to oak, 30 feet east to oak	32	21	59.4	84	46	51.7
Church and schoolhouse, 700 feet south of, four corners, 50 feet south to telephone pole, 20 feet west to double sweet gum	32	22	21.7	84	46	43.8
Four corners, crossing of Cusseta-Greenville and Columbus-Buena Vista roads	32	23	26.1	84	46	06.4
Northwest corner of schoolhouse yard, in southeast corner of intersection of above roads, iron post stamped "Prim. Trav. Sta. No. 4, Ga. 1906"	32	23	25.6	84	46	08.0
Four corners, second-class crossroads, 20 feet southwest to C. B. Underwood's mail box No. 16	32	24	17.5	84	46	11.2
Four corners at Cane Mill	32	24	54.2	84	46	04.9
Blair Branch, center of bridge over	32	25	33.6	84	45	52.8
Elbeck, 0.5 mile south of, three corners, 25 feet southeast to signboard "Cusseta 11 mi.," 20 feet south to oak	32	26	05.3	84	45	11.9
Muscogee and Chattahoochee county line, center of covered bridge over Upatoie Creek	32	26	42.3	84	45	24.2
Forks of road 0.3 mile northwest of bridge over Upatoie Creek	32	26	46.6	84	45	41.4
Forks of second-class road, 20 feet southeast to dead pine, 50 feet north to double oak	32	27	54.6	84	45	38.0
Forks of road south and southwest, 25 feet west to oak, 20 feet east to small persimmon tree	32	28	14.1	84	45	57.9
Four corners, 2 miles south of schoolhouse, 20 feet north to mail box No. 20, post painted "463"	32	29	27.6	84	45	49.6
Three corners, T road west, 10 feet southwest to mail box	32	30	07.4	84	45	37.1
Forks of road south and southwest, 50 feet south to pine painted "490".	32	30	50.3	84	45	15.6
Forks of road north and northeast, 10 feet north to persimmon painted "482"	32	31	23.5	84	45	01.9
Upatoie, 0.75 mile south of, forks of road north and northwest	32	32	12.4	84	44	38.7
Upatoie station, at south wall in angle between wall and operator's office, Central of Georgia Rwy., iron post stamped "Prim. Trav. Sta. No. 3, 1905"	32	32	49.6	84	44	25.1

ARKANSAS.

PRIMARY TRAVERSE.

CRAWFORD, FRANKLIN, LOGAN, SCOTT, AND SEBASTIAN COUNTIES.

FORT SMITH 30′ QUADRANGLE.

The following geographic positions on the United States standard datum were determined by primary traverse in 1905 by J. R. Ellis, assistant topographer. The line starts from the "initial point" at Fort Smith, runs northeast along the Missouri Pacific Railway to a point 5 miles northeast of Van Buren, thence along the Little Rock and Fort Smith Railroad to the east edge of the quadrangle, thence south on highways to Charleston, thence west on highways and the

Midland Valley Railroad to Hackett, thence along the St. Louis and San Francisco Railroad to the initial point. Another line starts from Hackett, follows the St. Louis and San Francisco and the Midland Valley railroads to Hartford, thence east along the Chicago, Rock Island and Pacific Railroad to Barber, thence north on highways to Charleston, and is tied to United States Geological Survey triangulation stations Peak and Pinnacle.

Geographic positions along Missouri Pacific Railway between Fort Smith and Lees Creek.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Fort Smith, at southwest corner of old fort about 50 feet from United States Coast and Geodetic Survey astronomical station, which was used as initial point. Station mark: A stone monument	35	23	16.91	94	25	51.35
Fort Smith, yard-limit post, private road crossing just north of	35	24	25.9	94	26	23.8
Arkansas-Indian Territory boundary post 74 M	35	25	56.7	94	26	16.2
Arkansas-Indian Territory boundary post 73 M, at Cherokee Junction	35	26	50.2	94	26	26.0
Milepost 509, private road crossing, 800 feet east of	35	27	08.2	94	25	17.0
Switch block to spur, road crossing northeast and southwest, 1,200 feet west of	35	27	05.8	94	23	53.0
Lees Creek, center of bridge over	35	27	03.7	94	22	56.0

Geographic positions along "Frisco" Railroad between Van Buren and Meadows.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Van Buren, in retaining wall to Doctor Kerr's front yard, 22 feet from corner of wall, aluminum tablet stamped "Prim. Trav. Sta. No. 1, 1905"	35	26	07.0	94	21	26.4
Van Buren, 1 mile north of, road crossing	35	26	32.2	94	20	15.7
Smeltzer station, road crossing just south of	35	27	22.6	94	19	37.4
Central pier of bridge No. 4071 over creek south	35	27	59.2	94	19	12.7
Milepost 406, road crossing north and south 810 feet east of	35	28	29.5	94	18	04.5
Meadows station, 0.66 mile west of, road crossing	35	29	09.0	94	16	35.1

Geographic positions along highways.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Meadows, 0.75 mile east of station, T lane, 16 feet due north to arrow on fence post	35	29	33.5	94	15	22.7
Alma, 1.5 miles northwest of, 1.75 miles east of Meadows, in southwest corner of J. W. Farris's field at crossroads, nail in root of black oak bears S. 50° 15′ E., distant 34.7 feet; stone at crossroads bears S. 53° 20′ W., distant 24.5 feet; iron post stamped "Prim. Trav. Sta. No. 2, 1905"	35	29	32.2	94	14	19.3

Geographic positions along Missouri Pacific Railway between Alma and Mulberry.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Alma, station	35	28	45.4	94	13	16.7
Alma, road crossing northeast and southwest, 1 mile east of station	35	28	55.7	94	11	56.0
Milepost 489, road crossing 0.25 mile west of	35	29	10.1	94	10	02.7
Dyer, center of trestle 0.33 mile west of	35	29	24.7	94	08	41.2
Dyer, in northeast corner of J. H. Selby's farm, on south side of railroad, 6 feet from right-of-way fence and 18 feet west of section line, iron post stamped "Prim. Trav. Sta. No. 3, 1905"	35	29	32.0	94	07	57.8
Milepost 486	35	29	46.3	94	06	41.2
Milepost 485, road crossing north and south 800 feet west of	35	29	47.3	94	05	46.7
Milepost 484, road crossing north and south 600 feet west of	35	29	40.3	94	04	42.8
Mulberry, on property of Oil Mill Co., 585 feet north to Main street crossing railroad, 10 feet east to north-south fence, in top of sandstone 30 by 10 by 10 inches, aluminum tablet stamped "Prim. Trav. Sta. No. 4, 1905"	35	29	35.9	94	03	06.5

Geographic positions along highways, Mulberry via Charleston to Greenwood.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Riffle ford, Big Mulberry Creek, arrow painted on birch tree 80 feet north of	35	28	53.1	94	02	33.3
Cross and arrow painted on white-oak tree on north side of road and on north side of River Hill about 0.25 mile north of summit, about 1,000 feet southeast of gate to field	35	27	02.1	94	02	08.0
Junction of telephone lines, T road north, just east of	35	26	38.8	94	01	30.2
Oak Grove, schoolhouse, northwest corner of	35	26	36.5	93	59	52.5
Pauline store, 0.25 mile southeast of, cross on walnut tree at forks of road	35	25	58.2	93	59	51.6
Pauline store, 1.5 miles west of, crossroads 12 feet due north to cross on sapling, 33 feet west to arrow on tree	35	25	46.4	94	01	48.0
Pauline store, cross and arrow painted on black-oak tree just south of point where Charleston road leaves Fort Smith and Ozark road, 2.5 miles west of Pauline	35	25	29.8	94	02	45.5
Millcreek Mountain, T road north 0.5 mile south of summit, 39 feet northwest to east end of stone fence, 12 feet east to cross on black oak	35	24	42.1	94	02	38.5
Vesta, in southwest corner of stone coping to public well, aluminum tablet stamped "Prim. Trav. Sta. No. 5, 1905"	35	22	44.4	94	02	28.4
T. 8 N., R. 29 W., corner secs. 11, 12, 13, and 14, at Vesta	35	22	44.2	94	02	28.4
T. 8 N., R. 29 W., corner secs. 13, 14, 23, and 24, T road west	35	21	50.0	94	02	29.7
Vesta crossroads, 2 miles south of, 22 feet northwest to nail in fence post, 39 feet southwest to cross on fence post	35	20	58.9	94	02	14.4
Peadget schoolhouse, 20 feet east to small bridge, 21 feet southeast to mail box	35	20	06.4	94	02	16.5
Charleston, "+ & →" painted on white-oak tree about 1 mile north of	35	18	41.1	94	02	16.5
Charleston, railway crossing, 65 feet east of station	35	17	39.7	94	02	10.3
Charleston, T road north, 1 mile south of	35	16	56.0	94	02	06.0
T. 7 N., R. 28 W., secs. 18, 19, west corner of	35	16	29.1	94	01	34.8
Charleston, 3 miles south and 0.5 mile east of, in southeast corner of field of Wert Haines at T road north nail in black-oak tree in road bears S. 44° E., distant 37 feet; in top of sandstone 32 by 7 by 6 inches, aluminum tablet stamped "Prim. Trav. Sta. No. 6, 1905"	35	15	14.6	94	01	37.7
T. 7 N., R. 29 W., secs. 23, 24, 25, 26, T road south at corner of	35	15	37.1	94	02	40.8
T. 7 N., R. 29 W., secs. 22, 23, 26, and 27, crossroads south at corner of	35	15	38.2	94	03	45.1
T. 7 N., R. 29 W., secs. 21, 22, 27, and 28, Franklin-Sebastian county line	35	15	39.0	94	04	49.2
T. 7 N., R. 29 W., secs. 20, 21, 28, 29, crossroads at corner of	35	15	39.8	94	05	53.8
T. 7 N., R. 29 W., secs. 19, 20, 29, 30, T road east, corner of	35	15	40.8	94	06	58.0
Auburn, in northeast corner of Brown's store, aluminum tablet stamped "Prim. Trav. Sta. No. 7, 1905"	35	15	14.7	94	07	37.9
Guideboard on tree at T road west, 1 mile west of Auburn	35	14	49.2	94	08	24.3
Hickory tree with iron ring at T road south, just south of white frame house	35	14	24.0	94	09	47.4
Black-oak tree, "+" and arrow painted on it, east of T road north	35	14	01.6	94	11	03.4
Garden, cross and arrow painted on corner of fence	35	13	41.4	94	12	03.2
Liberty Church, forks of road, 20 feet southeast to cross on post 63 feet southwest to corner of cemetery	35	13	03.6	94	13	26.2
Greenwood, in southeast corner of foundation to court-house, aluminum tablet stamped "Prim. Trav. Sta. No. 8, 1905"	35	12	43.5	94	15	17.9

Geographic positions along Midland Valley Railroad, Greenwood to Hackett.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Milepost 3, 1,300 feet west of, private-road crossing	35	11	55.4	94	16	23.6
Coal-mine shaft, crossing north and south 575 feet east of	35	11	39.4	94	18	24.8
Excelsior station	35	11	42.0	94	19	09.5
Milepost 2, road crossing 1,700 feet east of	35	11	40.2	94	20	55.3
Milepost 3, north-south road crossing 650 feet west of	35	11	22.7	94	22	24.5
Milepost 4, road crossing 600 feet west of	35	11	19.3	94	23	28.3
Midland Valley and "Frisco" R. R., crossing of	35	11	13.7	94	24	07.6
Hackett, in southwest corner of cotton gin owned by Clark & Johnson, aluminum tablet stamped "Prim. Trav. Sta. No. 9, 1905"	35	11	25.9	94	24	33.8

Geographic positions along "Frisco" Railroad, Hackett to Fort Smith.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Switch block, private crossing 700 feet east	35	11	42.0	94	25	35.7
Arkansas-Indian Territory (Choctaw) boundary post at Jenson, marked "No. 13 M 1877"	35	12	01.5	94	26	17.8
Tunnel, south end of	35	12	55.2	94	26	33.4
Arkansas-Indian Territory (Choctaw) boundary post marked "11 M 1877"	35	13	46.0	94	26	13.7
Trestle 4262, road crossing under	35	14	26.2	94	25	51.9
Arkansas-Indian Territory (Choctaw) boundary post marked "9 M 1877"	35	15	30.8	94	26	09.7
Cedars, station board	35	16	36.1	94	26	28.7
Milepost 422, road crossing east and west	35	17	49.9	94	26	22.2
Arkansas-Indian Territory (Choctaw) boundary post marked "5 M 1877"	35	18	59.9	94	26	01.4
Milepost 419, road crossing east and west 300 feet south of	35	20	20.5	94	25	47.1
Ward Siding, road crossing east and west	35	21	13.8	94	25	42.7
T. 8 N., R. 32 W., secs. 16, 17, 20, and 21, corner of	35	22	18.0	94	25	15.8

Geographic positions along "Frisco" Railroad, milepost 434 to 438.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Trestle 4340 and milepost 434, crossing under	35	09	45.0	94	22	29.5
Milepost 436	35	08	27.0	94	21	55.8
Milepost 437, private-road crossing 400 feet south of	35	08	25.4	94	21	01.0
Milepost 438	35	07	39.9	94	20	51.4

Geographic positions along Midland Valley Railroad, Montreal to Hartford.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Montreal, 3,200 feet southwest of, road crossing	35	07	07.1	94	21	32.5
T. 5 N., Rs. 31 and 32 W., corner secs. 7, 12, 13, and 18	35	07	06.6	94	21	37.4
Coal shaft, road crossing 800 feet north of	35	06	29.5	94	21	53.5
Midland City, 240 feet west of section house, in north corner of stone culvert, aluminum tablet stamped "Prim. Trav. Sta. No. 10, 1905"	35	05	45.7	94	21	46.4
Peak triangulation station, on a sharp summit of Sugarloaf Mountain, about 6 miles northeast of Sugarloaf Peak; station mark, a rock monument	35	04	25.24	94	22	21.85
Midland City, 1 mile south of, 700 feet north of milepost 10, road crossing	35	04	50.2	94	20	46.3
Milepost 11, road crossing just south of	35	03	53.4	94	20	25.0
Prairie Creek station	35	03	07.8	94	20	59.8
Trestle A 1311, road crossing under	35	02	24.7	94	21	38.5
Road crossing east and west	35	02	00.3	94	22	22.1
Hartford, road crossing 125 feet east of	35	01	44.3	94	22	58.5
Hartford, in southeast corner of stone step in front of Grand View Hotel, aluminum tablet stamped "Prim. Trav. Sta. No. 11, 1905"	35	01	15.2	94	22	53.1

Geographic positions along Chicago, Rock Island and Pacific Railroad between milepost 279 and Barber.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Milepost 279, road crossing 1,800 feet east of	35	01	30.6	94	21	52.4
Milepost 278, road crossing north and south 0.5 mile east of	35	01	45.9	94	20	16.4
Milepost 275, road crossing north and south 0.5 mile east of	35	02	24.9	94	17	25.0
Milepost 276, 950 feet west of	35	01	44.1	94	19	00.3
Road crossing north and south	35	03	03.1	94	16	20.8
T. 5 N., Rs. 30 and 31 W., south corner secs. 31 and 36	35	03	28.1	94	15	02.6
Mansfield, in northeast corner of restaurant yard opposite station, iron post stamped "Prim. Trav. Sta. No. 12, 1905"	35	03	28.8	94	14	35.0
Milepost 270, road crossing north and south 230 feet east of	35	04	00.4	94	13	07.3
Abbott station	35	04	29.9	94	11	39.4
Milepost 267, private-road crossing 1,000 feet east of	35	05	08.7	94	10	05.8
Milepost 266, 338 feet east of, 135 feet west of road crossing, in arch at south end of stone culvert, aluminum tablet stamped "Prim. Trav. Sta. No. 13, 1905"	35	05	13.1	94	09	09.3
Echo station board	35	05	57.0	94	07	45.4
Milepost 262, 705 feet west of, private-road crossing	35	06	35.1	94	06	45.7
Milepost 261, road crossing 1,065 feet west of	35	07	10.4	94	04	52.6
Barber, road crossing 0.5 mile west of	35	07	26.5	94	03	46.4
Barber, railroad bridge over Petit Jean River, in top of east end of center concrete pier, aluminum tablet stamped "Prim. Trav. Sta. No. 14 1905"	35	07	43.7	94	02	50.7

Geographic positions along highways, Barber to Pinnacle triangulation station.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Schoolhouse, forks of road just north of	35	08	29.1	94	02	39.7
Peach orchard, forks of road southeast at corner of, 15 feet southeast to corner rail fence near county line	35	08	52.1	94	02	03.6
Logan-Scott county line, road fork west on ridge 0.5 mile east of, 5 feet south to arrow painted on tree	35	09	07.6	94	01	33.4
Field on top of ridge, arrow and cross painted on tree at southeast corner of	35	09	39.5	94	01	08.1
Forks of road, arrow and cross painted on black oak 250 feet west of	35	10	11.7	94	00	40.1
Church, turn of road at north end of lane	35	10	35.4	94	01	09.0
Road north to schoolhouse, at turn of road 13 feet east to cross on fence post	35	10	40.2	94	02	13.5
Pleasant Ridge schoolhouse, in east face of bowlder which is partly overgrown by post-oak tree, aluminum tablet stamped "Prim. Trav. Sta. No. 15, 1905"	35	11	12.9	94	02	33.1
T road west about 0.5 mile south of Washburn Mountain	35	12	00.9	94	02	32.2
Pinnacle triangulation station, knob on ridge about 5 miles south of Charleston, with all timber cleared from summit; station mark, lone tree blazed near foot	35	12	47.77	94	03	11.44
Zion schoolhouse, crossroads 0.25 mile south of	35	14	06.1	94	03	48.2
T. 7 N., R. 29 W., secs. 26, 27, 34, and 35, corner of	35	14	45.5	94	03	47.6

ILLINOIS.

PRIMARY TRAVERSE.

MADISON AND CLINTON COUNTIES.

BREESE QUADRANGLE.

The following geographic positions on the United States standard datum were determined by primary traverse in 1905 by J. R. Ellis. The line starts from an adjusted position on the Belleville quadrangle 2 miles west of Highland and follows the Vandalia Railroad to Highland; thence east and south along highways to a point near the southeast corner of the quadrangle; thence west along highways to a point 3 miles east of New Baden, where it is run west over the

Southern Railway to primary traverse station No. 17. The line was tied to Breese and Damiansville triangulation stations, United States Coast and Geodetic Survey.

Geographic positions along Vandalia Railroad near Highland.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Highland, road crossing 2 miles west of	38	44	02.9	89	42	48.2
Highland, road crossing 1 mile west of	38	44	19.8	89	41	52.4
Highland, road crossing at station	38	44	38.5	89	40	50.5

Geographic positions along highways.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
German Cemetery, road in front of entrance, 70 feet due north to entrance	38	44	33.1	89	39	42.3
Tps. 3 and 4 N., R. 5 W., T road north near corner of secs. 2, 3, 34, and 35, 30 feet northwest to sycamore tree, 36 feet northeast to dead black oak	38	44	35.8	89	38	03.5
Tps. 3 and 4 N., R. 5 W., secs. 1, 2, 35, and 36, center of road at hedge fence north	38	44	34.7	89	36	56.8
Linenfilser (Fred) residence, 400 feet west of, in pasture, 5 by 5 by 24 inch stone; walnut tree bears N. 35° 45′ E., distant 40.4 feet; aluminum tablet in top of stone, stamped "Prim. Trav. Sta. No. 22, 1905".	38	44	35.1	89	36	40.3
Tps. 3 and 4 N., Rs. 4 and 5 W., corner secs. 1, 6, 31, and 36; also junction Madison, Clinton, and Bond counties; 19 feet southwest to west end of small bridge, 29 feet southeast to United States mail box	38	44	35.6	89	35	49.9
T road north, 15 feet north to center of small bridge	38	44	33.3	89	34	32.2
T road south, 27 feet northeast to William Frentiger's mail box	38	44	31.3	89	33	23.0
Jamestown, T road north, 1 mile west of, 27 feet southeast to dead locust tree	38	44	03.2	89	31	41.8
Jamestown public school grounds, near south line of, 57 feet east of southwest corner of grounds; southwest corner of school building bears N. 5° E., distant 144 feet; in top of dressed limestone 5 by 5 by 24 inches aluminum tablet stamped "Prim. Trav. Sta. No. 23, 1905".	38	43	59.7	89	31	06.9
T. 3 N., R. 4 W., corner secs. 2, 3, 10, and 11, at crossroads, 37 feet northwest to corner yard fence, 36 feet southeast to cross on gatepost.	38	43	36.1	89	31	07.2
T. 3 N., R. 4 W., corner secs. 14, 15, 22, and 23, at crossroads, 30 feet northeast to cross on corner fence post, 54 feet southeast to milk platform	38	41	51.1	89	31	03.6
T. 3 N., R. 4 W., west corner secs. 23 and 26, center of road at fence east just north of schoolhouse	38	40	58.7	89	31	02.3
T. 3 N., R. 4 W., corner secs. 26, 27, 34, and 35	38	40	06.5	89	31	01.0
H. Hinkam's farm, T road west, 42 feet east to wild cherry tree	38	38	56.9	89	31	00.1
State road crossing of north-south road, 24 feet north to cross on corner fence post, 63 feet southwest to cross on corner fence post	38	38	31.3	89	31	33.0
Breese, 1 mile north of, in northeast corner of Frank Budde's field, iron post stamped "Prim. Trav. Sta. No. 24, 1905"	38	37	30.4	89	31	32.0
Breese, Catholic Church spire	38	36	32.0	89	31	44.3
Crossroads, 27 feet northwest to west end of stone culvert, 30 feet southeast to Hem Ahler's mail box	38	35	47.0	89	32	06.4
Crossroads, 20 feet northwest to west end of culvert, 35 feet southwest to cross on telephone pole	38	34	54.6	89	32	06.1
Germantown, crossroads 1 mile north of, 18 feet north to center of bridge	38	34	02.2	89	32	06.3
Germantown, Catholic Church spire	38	33	13.2	89	32	15.9

Geographic positions along Southern Railway near Shoal Creek.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Shoal Creek, center of bridge over	38	32	46.4	89	30	47.5
Road crossing north and south	38	32	28.8	89	29	52.8

Geographic positions along highways.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
T road south at large wooden cross	38	32	11.0	89	29	02.9
Bartelso, 1.25 miles southwest of, at T road north, in southeast corner of field owned by Herman Soole; nail in blaze on tree bears N. 76° 45′ E., distant 39.8 feet; iron post stamped "Prim. Trav. Sta. No. 25, 1905"	38	31	44.8	89	29	02.8
Murch's schoolhouse, T road east, just south of, 25 feet northeast to cross on wild-cherry tree, 31 feet southeast to corner wire fence	38	31	41.8	89	30	24.9
Germantown, T road south 1.5 miles south of, 33 feet southeast to cross on post	38	31	47.1	89	31	31.6
Center of private road	38	31	44.2	89	33	00.9
T. 1 N., R. 4 W., corner secs. 8, 9, 16, and 17, T road north	38	32	16.1	89	33	12.3
T. 1 N., R. 4 W., corner secs. 7, 8, 17, and 18, crossroads, 36 feet northeast to large apple tree, 37 feet southeast to locust tree	38	32	17.5	89	34	18.2
T. 1 N., R. 4 W., east corner secs. 18 and 19	38	31	24.9	89	34	17.0
T. 1 N., R. 4 W., corner secs. 18 and 19 (west corner), 24 feet west to cross on rail fence, T road east	38	31	27.1	89	35	34.9
T. 1 N., R. 5 W., east corner secs. 24 and 25, T road west, 50 feet northwest to cross on fence, 39 feet west to south end of tile culvert	38	30	35.2	89	35	34.9
T. 1 N., R. 5 W., southwest corner sec. 24, 0.5 mile east of Damiansville, iron post stamped "Prim. Trav. Sta. No. 26, 1905"	38	30	36.3	89	36	42.2
Damiansville, Catholic Church spire	38	30	35.8	89	37	24.4
Damiansville schoolhouse, 1.25 miles west of T road east, 42 feet southeast to northwest corner of schoolhouse, 25 feet southwest to north end of small bridge	38	30	48.6	89	38	56.4

Geographic positions along Southern Railway near New Baden.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
New Baden, north-south road crossing about 3 miles east of, Southern Rwy. crossing	38	31	54.3	89	38	57.0
Milepost 34, private-road crossing	38	31	53.2	89	40	37.4
New Baden station	38	31	53.0	89	42	03.1
Milepost 31, road crossing north and south 170 feet west of	38	31	54.2	89	43	58.5
North-south road crossing of Southern Rwy. near southwest corner of field of J. B. Freese, iron post stamped "Prim. Trav. Sta. No. 17, 1905"	38	31	55.6	89	45	38.9

MENARD AND SANGAMON COUNTIES.

TALLULA QUADRANGLE.

The positions in the following list were determined by primary traverse, run in June, 1905, by E. L. McNair, topographer. The line begins at Browns Crossing, on the Wabash Railroad, at the western boundary of Sangamon County, and runs north on or near the county line to about the center of T. 18 N., R. 8 W., Menard County, thence east to Petersburg:

Geographic positions along highways.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Browns Crossing flag station, center of track at railroad crossing	39	43	27.0	89	59	04.4
T. 15 N., R. 8 W., secs. 15 and 22, near quarter corner between, T road west	39	44	23.7	89	59	04.9
T. 15 N., R. 8 W., sec. 10, near center of, in triangle of roads, at T road east, iron post stamped "Prim. Trav. Sta. No. 7, 1905"	39	45	51.5	89	59	05.6
T. 16 N., R. 8 W., near center sec. 34, three corners, T road south	39	47	34.4	89	59	07.0
T. 16 N., R. 8 W., secs. 27 and 34, quarter corner between, T road east.	39	48	00.5	89	59	02.6
T. 16 N., R. 8 W., secs. 21 and 22, quarter corner between, three corners, county-line road to north	39	49	19.1	89	59	37.2
T. 16 N., R. 8 W., secs. 9, 10, 15, and 16, corner of, T road east	39	50	37.4	89	59	37.8
T. 16 N., R. 8 W., secs. 3, 4, 9, and 10, corner, T road east	39	51	29.7	89	59	38.2
T. 16 N., R. 8 W., secs. 3 and 4, quarter corner between, three corners, T road to west	39	51	55.8	89	59	38.1
Ashland, 0.75 mile east of, T. 17 N., R. 8 W., secs. 27, 28, 33, and 34, corner of, at intersection of roads, at northwest corner, iron post stamped "Prim. Trav. Sta. No. 8, 1905"	39	53	14.4	89	59	39.1
T. 17 N., R. 8 W., northwest corner of Sangamon County, T road to east.	39	53	55.5	89	59	39.0
T. 17 N., R. 8 W., secs. 15, 16, 21, and 22, corner of	39	54	59.6	89	59	39.8
T. 17 N., R. 8 W., secs. 9, 10, 15, and 16, corner of, T road west	39	55	51.9	89	59	40.5
T. 17 N., R. 8 W., secs. 3 and 4, quarter corner between, four corners	39	57	10.3	89	59	41.6
Tps. 17 and 18 N., R. 8 W., secs. 4 and 33, quarter corner between	39	57	36.0	90	00	15.4
T road south, in western part sec. 28	39	58	53.8	90	00	43.6
T. 18 N., R. 8 W., secs. 27 and 28, quarter corner between, T road south, Menard and Cass county line	39	58	54.2	89	59	42.3
T. 18 N., R. 8 W., secs. 21, 22, 27, and 28, corner of	39	59	20.2	89	59	42.4
T. 18 N., R. 8 W., secs. 15 and 16, quarter corner between, in grass triangle in center of road south and 25 feet south of center of east-west road, 450 feet west of farm house of Amos Shoneweise, iron post stamped "Prim. Trav. Sta. No. 9, 1905"	40	00	38.2	89	59	42.6
T. 18 N., R. 8 W., secs. 14 and 15, quarter corner between, T road to south	40	00	38.5	89	58	34.9
T road to north, in creek bottom	40	00	51.1	89	57	26.9
T. 18 N., Rs. 7 and 8 W., secs. 13 and 18, quarter corner between, four corners	40	00	38.6	89	56	17.9
T road south in western part of sec. 17	40	00	39.2	89	55	02.8
T. 18 N., R. 7 W., secs. 15 and 16, quarter corner between, T road south.	40	00	39.2	89	53	03.3
Overhead crossing of Chicago and Alton R. R	40	00	39.5	89	51	36.8
Petersburg station, Chicago, Peoria and St. Louis Rwy., center of track	40	00	41.20	89	50	46.40

LAKE COUNTY.

WAUKEGAN QUADRANGLE.

In June, 1906, L. E. Tucker, topographic aid, ran a line of primary traverse around the borders of this quadrangle, starting at Benton triangulation station, United States Lake Survey, and tying to primary traverse post No. 1 of 1904.

Magnetic declination, north border, 3° 05′ east; south border, 2° 34′ east; west border, 3° 58′ east.

Geographic positions along highways.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Benton triangulation station, U. S. Lake Survey, in NW. ¼ NW. ¼ sec. 7, Benton Township. Station mark: A stone post 2½ feet below surface, with another directly over it as a surface mark. Height of station used was 65 feet. Reference marks: Two stone posts, one S. 13° 04′ W., distant 565.9 meters; one N. 68° 59′ E., distant 19.65 meters. Height of ground at station above mean level of Lake Michigan, 212.6 feet	42	29	02.88	87	52	43.35
T. 46 N., R. 12 E., quarter corner secs. 7 and 8, four corners, North Prairie Church on northeast corner; schoolhouse on northwest corner	42	28	44.2	87	51	46.8
Chicago and Milwaukee Electric R. R. and Winthrop Harbor road, crossing of	42	28	43.9	87	50	41.9

Geographic positions along Chicago and Northwestern Railway, Zion City to Lake Forest.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Zion City, corner of Shiloh boulevard and Elijah avenue, northeast corner of American Express office 90 feet southwest	42	26	59.2	87	49	31.0
Zion City, Shiloh boulevard and Chicago and Northwestern Rwy. crossing, west rail	42	26	59.0	87	49	04.4
East-west road crossing	42	23	04.8	87	49	26.3
Waukegan court-house	42	21	36.8	87	49	56.4
Chicago and Northwestern and Elgin, Joliet and Eastern Rwys., crossing of	42	19	29.9	87	50	20.6
Road crossing, east and west	42	18	32.2	87	50	46.8
Chicago and Northwestern Rwy. and Chicago and Milwaukee Electric R. R., overhead crossing of	42	16	45.3	87	50	47.9
Chicago and Northwestern Rwy., overhead crossing	42	15	27.7	87	50	28.2
Lake Forest, in southeast corner of city hall yard, corner of Forest and Deerpatt streets; southeast corner of city hall bears N. 63° 30′ W., distant 34.5 feet; northwest corner of Chicago Telephone Co.'s building bears S. 41° 30′ E., distant 77.3 feet; iron post stamped "Prim. Trav. Sta. No. 12, 1906"	42	15	03.9	87	50	28.7
Chicago and Northwestern R. R. and highway crossing	42	14	49.4	87	51	42.1

Geographic positions along highways.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Tps. 43 and 44 N., Rs. 11 and 12 E	42	14	23.8	87	53	09.4
Tps. 43 and 44 N., R. 11 E., secs. 36 and 35 and 1 and 2	42	14	24.2	87	54	19.6
Tps. 43 and 44 N., R. 11 E., approximate corner secs. 35, 34, 3, and 2	42	14	24.7	87	55	30.0
Des Plaines River, on south side of town-line road, 9.8 feet southwest of corner of iron bridge across river; an 8-inch oak on opposite side of road is 22 feet north; iron post stamped "Prim. Trav. Sta. No. 13, 1906"	42	14	25.6	87	56	21.5
Milwaukee road and town line, corner of	42	14	25.3	87	56	39.7
Four corners east of railroad crossing	42	14	25.3	87	58	36.2
Wisconsin Central Rwy., azimuth of, at station 69, 152° 01′.						
Diamond Lake, in southwest corner of schoolhouse No. 76, Union, 5 feet north of school-yard corner; southwest corner of schoolhouse is 83.6 feet northeast; southeast corner of Wm. Einzewam's house is 20.5 feet northwest by west; iron post stamped "Prim. Trav. Sta. No. 14, 1906"	42	14	29.1	88	00	13.4
Elgin, Joliet and Eastern Rwy., azimuth from station 77, 282° 51′.						
Three corners, road east	42	15	18.5	88	00	05.0
Rockefeller, Hotel Cameron, center of street crossing	42	16	25.2	88	00	14.1
Wisconsin Central Rwy. and highway crossing	42	17	51.7	88	00	17.4
Four corners	42	18	21.5	88	00	15.2
Tps. 44 and 45 N., Rs. 10 and 11 E	42	19	39.9	88	00	16.3
Gages Corners	42	20	19.2	88	00	16.1
Three corners, road west	42	21	37.8	88	00	06.5
Druses Lake, at three corners 600 feet north of north shore of, opposite Brown's cottage; fence corner on west of road is 29.5 feet south; blazed oak is 26.7 feet north; W. C. Brewer's mail-box post No. 4 at corner is 22 feet southeast; iron post stamped "Prim. Trav. Sta. No. 15, 1906"	42	22	17.8	88	01	12.8
Road crossing	42	23	09.6	88	00	14.5
T. 45 N., R. 10 E., secs. 1 and 12	42	24	02.1	88	00	14.1
T. 45 N., R. 11 E., corner secs. 6 and 7	42	24	02.1	88	00	14.1
Township corner	42	24	54.5	88	00	13.6
Four corners, road east and west, northwest and southeast	42	26	39.4	88	00	37.4
Hickory Corners, an oak tree is 35 feet northeast, Methodist Church is on southwest corner, mail box No. 69 is 35 feet northwest	42	27	58.1	88	01	01.4
Three corners, road west, schoolhouse on northwest corner	42	28	24.1	88	01	04.5
Pikeville, Wis., four corners, south side State-line road, west side north-south road; fence corner on southwest corner is 30 feet southwest	42	29	44.5	88	01	30.3
T. 1 N., R. 21 E., 50 feet northeast of south corner of secs. 34 and 35, north side State-line road, 800 feet northwest of Chas. Crawford's house; iron post stamped "Prim. Trav. Sta. No. 1, 1904"	42	29	42.5	87	59	24.5

DUPAGE COUNTY.

WHEATON QUADRANGLE.

The following geographic positions were determined by primary traverse by E. L. McNair, topographer, in June, 1905. The line starts at Lombard triangulation station of the United States Lake Survey, near Lombard, Ill., and runs north to Itasca, on the Chicago, Milwaukee and St. Paul Railway; thence west along railway and highway to a point near the northwest corner of Dupage County; thence south along Elgin, Joliet and Eastern Railway and highway to a point about 1.5 miles east of the southwest corner of Dupage County; thence easterly via highways to quarter corner between secs. 27 and 28, Downers Grove Township; thence north to point of beginning.

Geographic positions from Lombard triangulation station North to Chicago, Milwaukee and St. Paul Railway.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Lombard triangulation station, U. S. Lake Survey, in NW. ¼ sec. 4, York Township. Station mark: A stone post 3 feet below surface. Reference marks: Three stone posts, one N. 8° 52′ W., distant 117.93 meters; one N. 85° 11′ E., distant 150.05 meters; and one at center of sec. 4, S. 13° 05′ E., distant 575.32 meters	41	54	07.69	87	59	24.29
T. 39 N., R. 11 E., four corners, quarter corner north side sec. 5	41	54	17.6	88	00	28.4
T. 40 N., R. 11 E., quarter corner north side sec. 32, four corners east, west, and south	41	55	10.3	88	00	29.5
T. 40 N., R. 11 E., sec. 20, four corners	41	56	18.4	88	00	11.8
Itasca, 0.06 mile southeast of station, road corners east, west, and south.	41	58	02.4	88	00	11.0
Itasca, 400 feet southeast of Chicago, Milwaukee and St. Paul Rwy. station, vertical face of west wing wall, north abutment of highway bridge over creek, 100 feet south of railway tracks, aluminum tablet stamped "Prim. Trav. Sta. No. 1, 1905"	41	58	16.2	88	00	46.8

Geographic positions along Chicago, Milwaukee and St. Paul Railway, Itasca to Bartlett.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Meacham, 0.75 mile east of station, road crossing	41	58	31.2	88	02	11.1
Meacham, center of south track opposite station	41	58	41.9	88	03	04.1
Roselle, center of south track opposite station	41	59	00.2	88	04	35.5
Roselle, 1.75 miles west of station, road crossing	41	59	22.4	88	06	34.9
Ontarioville, center of south track opposite station	41	59	18.6	88	09	11.8
Bartlett station, center of track opposite semaphore	41	59	32.9	88	11	09.2
Bartlett, 0.6 mile west of station, road crossing	41	59	41.0	88	11	51.5
Bartlett, 1.75 miles west of, on highway, four corners	41	59	40.0	88	13	03.8

Geographic positions along Elgin, Joliet and Eastern Railway.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Road crossing near water tank 0.5 mile south of Chicago, Milwaukee and St. Paul Rwy. junction	41	59	38.8	88	14	11.1
Illinois Central R. R. crossing, 0.5 mile north of, road crossing	41	58	32.7	88	14	12.0
Illinois Central R. R. crossing, in vertical face of south abutment of overhead bridge 10 feet south of Illinois Central track, in line with center of Elgin, Joliet and Eastern Rwy. track, aluminum tablet stamped "Prim. Trav. Sat. No. 2, 1905"	41	58	05.0	88	14	12.4
Chicago, Aurora and Elgin Third Rail Electric Line	41	56	50.3	88	14	13.4
Chicago, Aurora and Elgin Third Rail Electric Line, road crossing 0.75 mile south of	41	56	09.7	88	14	14.0

Geographic positions along highways in Wayne and Winfield townships.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Chicago Great Western Rwy. crossing, T. 40 N., R. 9 E., Wayne Township, in NW. ¼ sec. 32	41	54	33.0	88	14	16.2
T. 40 N., R. 9 E., Wayne Township, near southwest corner sec. 32, road corners east, west, and south	41	53	58.0	88	14	34.1
T. 39 N., R. 9 E., Winfield Township, in northeast corner sec. 7, Chicago and Northwestern Rwy. crossing	41	52	58.7	88	14	36.4
Chicago, Burlington and Quincy Rwy. crossing of branch line in eastern part of sec. 18, T. 39 N., R. 9 E. (Winfield Township)	41	51	57.3	88	14	3[illegible].1
T. 39 N., R. 9 E., near line between secs. 17 and 18, Chicago, Burlington and Quincy Rwy. branch line from West Chicago to Aurora, 672 feet northeast of north-south road, in north end of east abutment of open culvert, aluminum tablet stamped "Prim. Trav. Sta. No. 3, 1905"	41	52	00.9	88	14	28.7
T. 39 N., R. 9 E., Winfield Township, in sec. 19, road corners east, west, and north	41	50	55.0	88	14	37.7
T. 39 N., R. 9 E., Winfield Township, near center sec. 32, four corners	41	49	13.0	88	13	[illegible]

Geographic positions along Elgin, Joliet and Eastern Railway in Naperville Township.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
T. 38 N., R. 9 E., in eastern part of sec. 5, Naperville Township, road crossing	41	48	39.1	88	13	33.3
T. 38 N., R. 9 E., sec. 8, Naperville Township, Chicago, Aurora and Elgin Electric Rwy. crossing	41	47	49.3	88	13	45.6
Frontenac siding, 2 miles north of crossing Chicago, Burlington and Quincy Rwy. main line	41	46	36.1	88	13	54.2
Frontenac siding, 1 mile north of, road crossing	41	45	36.8	88	13	58.2
Frontenac siding, road crossing	41	44	41.3	88	13	59.[illegible]
Frontenac siding, 0.75 mile south of, road crossing	41	43	56.4	88	14	03.[illegible]

Geographic positions along highway from southwest corner of Naperville Township eastward to southern half of Downers Grove Township.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
T. 38 N., R. 9 E., quarter corner between secs. 33 and 34, Naperville Township, Copenhagen Church on northeast corner, four corners	41	43	57.7	88	12	2[illegible]
T. 38 N., R. 9 E., quarter corner between secs. 34 and 35, Naperville Township, four corners	41	43	58.5	88	11	11.[illegible]
Road corners north, south, and west; quarter corner between secs. 35 and 36, Naperville Township	41	43	59.5	88	10	01.7
T. 38 N., R. 9 E., quarter corner between secs. 25 and 26, Naperville Township, road corners east, west, and south	41	44	52.0	88	10	01.[illegible]
T. 38 N., R. 10 E., in sec. 30, Lisle Township, road corners northwest, southeast, and south	41	45	22.7	88	08	30.9
T. 38 N., R. 10 E., sec. 30, 400 feet west of farmhouse of H. Haight, 400 feet east of iron truss highway bridge, in capstone at north end of stone arch culvert, Lisle Township; aluminum tablet stamped "Prim. Trav. Sta. No. 5, 1905"	41	45	05.6	88	07	44.[illegible]
T. 38 N., R. 10 E., north part of sec. 28, Lisle Township, road corners east, west, and north	41	45	23.1	88	05	55.9
T. 38 N., R. 10 E., in SW. ¼ sec. 23, Lisle Township; schoolhouse on northeast corner; four corners	41	45	39.0	88	03	54.0
T. 38 N., R. 10 E., center sec. 25, Lisle Township; road corners north, south, and east	41	45	01.7	88	02	36.[illegible]
T. 38 N., Rs. 10 and 11 E., quarter corner between secs. 25 and 30, Lisle and Downers Grove townships, four corners	41	45	02.8	88	01	51.0
T. 38 N., R. 11 E., sec. 29, Downers Grove Township, road corners east, west, and north	41	45	04.5	88	00	2[illegible]
T. 38 N., R. 11 E., quarter corner between secs. 28 and 29, Downers Grove Township; road corners	41	45	05.4	87	59	33.[illegible]
T. 38 N., R. 11 E., quarter corner between secs. 27 and 28, four corners	41	45	06.8	87	58	25.4

Geographic positions along highways north through Downers Grove Township to Lombard triangulation station.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
T. 38 N., R. 11 E., corner secs. 15, 16, 21, and 22, four corners, Downers Grove Township	41	46	25.4	87	58	28.0
T. 38 N., R. 11 E., corner secs. 9, 10, 15, and 16, four corners, Downers Grove Township	41	47	17.6	87	58	30.0
Greggs flag station on Chicago, Burlington and Quincy Rwy., road crossing	41	47	44.2	87	58	30.9
Greggs flag station, 0.6 mile east of, in capstone at south end of arch culvert, 11 feet south of center of south track, aluminum tablet stamped "Prim. Trav. Sta. No. 4, 1905"	41	47	44.1	87	57	49.5
T. 38 N., R. 11 E., quarter corner between secs. 3 and 4, Downers Grove Township, four corners	41	48	36.5	87	58	32.8
Road corners east, west, and north, sec. 33, York Township, T. 39 N., R. 11 E	41	49	27.1	87	59	27.5
T. 39 N., R. 11 E., sec. 28, York Township, four corners	41	50	35.7	87	59	26.0
York Center, four corners	41	51	38.2	87	59	33.4
T. 39 N., R. 11 E., on line between secs. 9 and 16, four corners	41	52	30.5	87	59	36.2

INDIANA-KENTUCKY.

PRIMARY TRAVERSE.

CLARK, FLOYD, AND HARRISON COUNTIES, IND.; BULLITT, JEFFERSON, AND OLDHAM COUNTIES, KY.

LOUISVILLE, NEW ALBANY, PROSPECT, AND RIVERVIEW QUADRANGLES.

The following geographic positions were determined by primary traverse run in 1904 by J. R. Ellis. The line starts from the Louisville Blind Asylum, a triangulation station of the United States Coast and Geodetic Survey, and runs southward on the Louisville and Nashville Railroad to Shepherdsville, thence eastward via highways to Mount Washington, thence northward via highways to Anchorage, thence westward over the Louisville and Nashville Railroad to the starting point at Louisville. A line was also run from Mount Washington southeast to Smithville and return. A spur line was run over highways from Shepherdsville west via Capio to West Point; also one from Anchorage northeast over the Louisville and Nashville Railroad to Beard, and thence northward along highways via Brownsboro and Skylight to Westport.

In 1905 C. B. Kendall ran two lines of primary traverse—namely, from Anchorage to Hatton and from Smithville to Gudgel, on the Frankfort quadrangle—in order that the positions determined by Mr. Ellis on the Louisville astronomic datum could be reduced to the United States standard datum. A correction of −2.38″ in latitude and +3.16″ in longitude has therefore been applied to the original computed values to reduce them to the United States standard datum.

Mr. Kendall also ran lines of traverse in Indiana around the borders of the Prospect, New Albany, and Riverview quadrangles, tying to Westport and West Point, and thus closing circuits on traverse positions located by Mr. Ellis at those places.

LOUISVILLE AND PROSPECT QUADRANGLES (BULLITT, JEFFERSON, AND OLDHAM COUNTIES, KY.; CLARK AND FLOYD COUNTIES, IND.).

Louisville quadrangle (Bullitt and Jefferson counties, Ky.).

Geographic positions at Louisville.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Louisville, Blind Asylum triangulation station, center of cupola	38	15	23.07	85	42	47.40
Louisville, Story street crossing of Louisville and Nashville R. R. (Short Line division)	38	15	18.4	85	43	45.3
Louisville, Catholic Cathedral, Fifth and Walnut streets, triangulation station, center of spire	38	15	05.63	85	45	32.00
Louisville, Ohio River survey, United States Army Engineers (1903), station 602 M +285 feet	38	15	31.66	85	45	54.7

Geographic positions along Louisville and Nashville Railroad between Highland Park and Shepherdsville.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Milepost 179	38	09	37.4	85	44	57.8
Hoertz station, road crossing	38	08	16.9	85	44	36.2
Private road crossing east and west	38	07	34.5	85	44	24.9
South Park, road crossing at section house	38	06	57.0	85	44	14.9
South Park, in southwest corner of field owned by South Park Co., southeast corner of Louisville and Nashville R. R. station bears 7° W., distant 112 feet; cross on stone wall to south end of culvert bears N. 69° W., distant 19.7 feet; cemented in stone, aluminum tablet stamped "Prim. Trav. Sta. No. 31"	38	06	34.9	85	44	08.4
Coral Ridge station, road crossing	38	05	32.7	85	43	32.2
Riley triangulation station, United States Coast and Geodetic Survey, on knob owned by W. H. Riley, Brooks post office station mark; a stone post 24 by 4 by 4 inches, set in ground above an earthenware pyramid	38	05	29.21	85	42	49.7
Brooks station, road crossing 1.5 miles north of	38	04	57.8	85	43	07.5
Brooks station, road crossing	38	03	39.3	85	42	37.8
Fox Ridge, station board	38	02	46.5	85	42	36.4
Hubers station	38	01	59.7	85	42	34.2
Pike crossing	38	00	58.0	85	42	14.4
Private-road crossing	38	00	21.2	85	42	30.5
Shepherdsville, in northwest corner of court-house yard, northwest corner of water table bears S. 23° 40′ E., distant 77.7 feet; northwest corner of court-house yard is 2.2 feet northwest; iron post set 42 inches in the ground, stamped "Prim. Trav. Sta. No. 32"	37	59	16.6	85	42	39.9

Geographic positions along highways.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Shepherdsville, 1.25 miles east of, T road northwest, 48 feet west to mail box, 40 feet north to cross on gatepost	37	59	53.2	85	41	44.2
Floyds Fork, center of bridge over	38	00	21.2	85	40	51.1
T road northwest, 40 feet west to cross on telephone pole, 25 feet south to cross on fence post	38	00	42.8	85	39	01.7
Pleasant Grove schoolhouse, T. Wise's mail box on telephone pole	38	01	14.7	85	38	05.1
Stallings's (William) garden, at northwest corner of, nail in blazed walnut tree, bears N. 33° 30′ W., distant 44.2 feet; northwest corner of Stallings's house bears S. 78° 40′ E., distant 153.4 feet; iron post set 40 inches in ground, stamped "Prim. Trav. Sta. No. 35"	38	01	30.3	85	36	59.9
Bethel Church, T road north at, 37 feet west to W. Boss's mail box, 15 feet south to corner stone on south side of road	38	01	55.5	85	35	45.8
Road south, 18 feet southeast to R. H. Hall's mail box, 44 feet southwest to cross on corner fence post	38	02	11.7	85	34	15.4
Mount Washington, road southeast 0.5 mile southwest of, 15 feet north to cross on board fence, 50 feet east to cross on corner fence post	38	02	33.5	85	32	53.8
Mount Washington, intersection of roads in south part of, 27 feet east to telephone pole, 48 feet north to telephone pole	38	02	49.9	85	32	31.8
Road southwest, 15 feet north to cross on fence post, 25 feet southwest to cross on corner post	38	03	24.8	85	30	59.8
Blacksmith shop, crossroads at, 33 feet southeast to corner fence post, 39 feet southeast to arrow on fence	38	03	57.1	85	30	08.2

Geographic positions along highways—Continued.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Ting post-office, 0.5 mile northeast of T road northwest, 24 feet east to cross on fence post 36 feet north to persimmon sapling	38	04	39.8	85	29	53.1
Road southeast at branch, 24 feet east to cross on picket fence, 36 feet southwest to arrow on fence	38	05	15.8	85	29	04.9
Whitfield, road west 1 mile southwest of, 900 feet northeast of schoolhouse	38	05	35.5	85	28	31.8
Bullitt-Jefferson county line, stone platform in front of brick house	38	05	56.5	85	29	11.9
Forks of road, 30 feet south to walnut tree, 60 feet northwest to cross on large sycamore tree	38	06	27.1	85	30	05.7
Malott post-office, 1.2 miles south of, in corner of field of O. E. Georger; southeast corner of Georger's house bears N. 10° 40′ E., distant 147.2 feet; cross on foundation to stable bears S. 60° 20′ W., distant 54.6 feet; iron post stamped "Prim. Trav. Sta. No. 37"	38	07	18.8	85	30	10.0
Floyds Fork, south end of covered bridge over	38	07	55.6	85	31	05.9
Bridwells's (Thomas) residence, small pasture in front of, center of gate to	38	09	02.3	85	30	33.2
Large white-oak tree, cross mark on	38	09	27.2	85	29	55.2
Crossroads, 50 feet south to corner stone of fence, 28 feet northwest to cross on corner fence post	38	09	59.6	85	31	09.6
Road west, 30 feet northwest to cross on corner rail fence, 16 feet east to small locust tree	38	10	36.6	85	32	02.9
Heddy road, south at Taylorsville pike, 18 feet north to cross on fence post, 43 feet southeast to cross on telephone pole	38	11	08.4	85	32	09.0
Tucker station, crossing of Southern Rwy. 0.25 mile east of	38	11	54.1	85	31	38.5
Center small bridge	38	12	32.0	85	31	43.3
T pike east, 25 feet southeast to mail box, 20 feet northeast to east end of tile culvert	38	13	52.8	85	31	49.6
Middletown, cross streets at Methodist Church, 41 feet southwest to iron pump, 30 feet southeast to cross on telephone pole	38	14	41.9	85	32	23.1
T road west, 34 feet southwest to stone gatepost, 19 feet southwest to cross on corner yard fence post	38	15	18.8	85	32	38.4

Geographic positions along highways between Mount Washington and Smithville.

[Double spur line.]

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Mount Washington, road northeast 1.3 miles southeast of, 48 feet to cross on corner fence post, 42 feet southeast to cross on corner rail fence	38	01	53.0	85	31	39.9
Road south, 21 feet west to mail box, 30 feet southeast to cross on fence post	38	01	07.6	85	31	20.1
Smithville, in lot at north corner of J. W. Markwell's front yard; northwest corner of Markwell's house bears S. 8° 45′ E., distant 86.9 feet; cross on corner of top corner stone to wall on opposite side of road bears N. 53° 15′ E., distant 55.1 feet; iron bench-mark post set 36 inches in ground, stamped "Prim. Trav. Sta. No. 36"	38	00	46.2	85	30	52.4

Prospect quadrangle (Jefferson and Oldham counties, Ky.; Clark and Floyd counties, Ind.).

Geographic positions along the Louisville and Nashville Railroad between Anchorage and Louisville, Ky.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Anchorage, in circular park about 300 feet northwest of club house; top of east stone gatepost to entrance to Clark property bears N. 79° 15′ W., distant 106.3 feet; south rail of south track at road crossing near park bears N. 55° 30′ E., distant 61.8 feet; iron post stamped "Prim. Trav. Sta. No. 38"	38	15	47.4	85	32	19.2
Lakeland station	38	16	10.8	85	33	16.2
Milepost 10, road crossing 540 feet west of	38	16	10.5	85	34	40.3
Lyndon, pike crossing 380 feet west of	38	15	41.7	85	36	25.1
Beechwood station, north track opposite	38	15	29.4	85	37	48.3
St. Matthews, in northeast corner of public school; northeast corner of schoolhouse bears S. 30° 40′ E., distant 171.1 feet; south rail of L. and E. Electric R. R. bears N. 10.6 feet; in stone post set in ground, tablet stamped "Prim. Trav. Sta. No. 41"	38	15	10.2	85	39	37.0
Louisville, road crossing at entrance to city reservoir	38	15	15.3	85	40	51.1

Geographic positions along Louisville and Nashville Railroad, Anchorage to Beard.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Forest station, road crossing 0.33 mile south of	38	15	58.9	85	31	34.0
O'Bannon station, road crossing 600 feet north of	38	17	18.8	85	30	45.0
Pewee Valley station, road crossing about 300 feet west of	38	18	31.8	85	29	22.1
Beard, road crossing at station	38	19	22.3	85	28	21.4

Geographic positions along highway, Beard to Westport (Kentucky).

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Beard, Y roads 2 miles north of, 20 feet east to cross on fence post, 46 feet northeast to cross on sycamore tree	38	20	39.7	85	29	29.9
Brownsboro, in southeast corner of schoolhouse yard; northeast corner of east stone gatepost to entrance to school yard bears N. 41° 50′ W., distant 87.3 feet; cross cut on southeast corner of foundation to schoolhouse bears N. 36° 20′ E., distant 262.3 feet; iron post stamped "Prim. Trav. Sta. No. 39"	38	21	27.9	85	30	00.4
Speers's (J. T.) residence, intersection of pikes, 16 feet southeast to cross on telephone pole, 27 feet north to mail box	38	21	56.0	85	30	40.1
Center of gate at north end of lane, county road enters gate	38	22	49.3	85	30	54.7
Turn of road at northeast corner of small bridge	38	24	26.4	85	32	04.5
T road southwest at two gates, corner stone	38	24	52.7	85	31	27.9
Crossing of Louisville pike and dirt road at church, 27 feet west to mail box, 37 feet east to cross on telephone pole	38	25	27.6	85	32	14.1
Skylight, road northwest, 30 feet north to corner fence post, 24 feet southeast to northwest corner blacksmith shop	38	25	56.6	85	31	18.2
Road south, 24 feet north to cross on board fence, 33 feet southwest to cross on beech tree	38	26	02.0	85	30	06.0
T road north, 15 feet southwest to cross on telephone pole, 27 feet northwest to cross on corner fence post	38	26	26.8	85	29	11.6
Westport, cross on face of south gatepost to gate across road	38	28	08.0	85	28	47.5
Westport, center of crossing of Main and Third streets	38	28	42.4	85	28	31.8
Westport, in northeast corner of public school grounds; cross on stone foundation at northeast corner of schoolhouse bears S. 15° 10′ W., distant 140 feet; northwest corner wall to cemetery bears S. 32° 55′ E., distant 130.3 feet; iron bench-mark post stamped "Prim. Trav. Sta. No. 40"	38	28	46.46	85	28	25.93

The following geographic positions on the United States standard datum were obtained from primary traverse run in 1905 by C. B. Kendall, field assistant. The line starts from Louisville, Ky., with position of cupola of the Catholic Cathedral, near corner of Fifth avenue and Walnut street and runs north along Fifth avenue to Ohio River, which was crossed by triangulation into Jeffersonville. The line then follows the Pittsburg, Cincinnati, Chicago and St. Louis Railway north to Chaney station, thence east along public highways to Westport, Ky., closing on traverse position at that place.

Geographic position at Jeffersonville, Ind.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Jeffersonville, crossing Baltimore and Ohio Southwestern and Pennsylvania Inter-Urban R. Rs., center of tracks	38	16	26.6	85	44	52.6

Geographic positions along Pittsburg, Cincinnati, Chicago and St. Louis Railway (Indiana).

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Jeffersonville, crossing Baltimore and Ohio Southwestern R. R. and Pittsburg, Cincinnati, Chicago and St. Louis Rwy, center of	38	16	59.7	85	44	37.8
Jeffersonville, 2.2 miles north of, road crossing, center of track	38	18	13.5	85	45	05.2
Pennsylvania and Baltimore and Ohio R. Rs., crossing, 500 feet north of, center of track at road crossing	38	19	11.3	85	45	04.6
Cementville station, 0.7 mile south of, road crossing, center of track	38	20	23.4	85	44	52.5
Cementville station, 200 feet north of, pike crossing, center of main track	38	20	59.4	85	44	45.6
Cementville, 1.5 miles north of, road crossing, center of track	38	22	13.8	85	44	46.0
Sellersburg station. 150 feet south of, street crossing, center main track.	38	23	40.9	85	45	01.2
Sellersburg, at south end of station, iron post stamped "Prim. Trav. Sta. No. 1, 1905'	38	23	42.5	85	45	01.6
Speeds station, 250 feet south of, road crossing, center of track	38	24	40.5	85	45	08.8
Speeds station, 1 mile north of, center of track at second-class road crossing	38	25	36.1	85	45	17.9
Milepost "L 14," 500 feet south of, road crossing and east-west township line, center of track	38	26	34.9	85	45	46.8
Milepost "L 15," 800 feet north of, road crossing, center of track	38	27	39.0	85	46	00.6
Milepost "L 16," 400 feet south of, second-class road crossing, center of track	38	28	18.4	85	45	52.5
Memphis station, 475 feet north of, Main street crossing, center of track.	38	29	00.8	85	45	42.1
Chaney station, road crossing, center of track	38	30	24.6	85	45	53.7
Chaney station, in northeast corner of intersection of public crossroads, 90 feet east of Chaney station signal tower, 95 feet northeast of road crossing, iron post stamped "Prim. Trav. Sta. No. 2, 1905"	38	30	25.2	85	45	52.9

Geographic positions along highways on north border of quadrangle (Indiana).

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Chaney, 1.7 miles northeast of station, in southeast corner of intersection of four corners, township line between Monroe and Union townships	38	31	50.2	85	45	26.6
Three corners at top of hill, public T road to northeast, 30 feet southeast to telephone pole, 20 feet southwest to telephone pole	38	31	41.7	85	44	17.6
Church and cemetery, 0.5 mile west of, four corners, 30 feet southeast to oak, 12 feet north to old gatepost	38	31	49.6	85	43	31.1
Church and cemetery, 1 mile east of, three corners, T road northwest, center of triangle	38	30	59.0	85	42	26.3
Three corners, public T road to southwest, 40 feet south to walnut, 40 feet northwest to walnut	38	30	15.2	85	41	42.2
Three corners at white house, 50 feet southeast to apple tree, 30 feet west to corner front yard fence	38	29	41.2	85	40	49.8
Three corners at small two-story house, about 3 miles north of Charlestown, T road to northwest, telephone pole at corners	38	29	09.0	85	40	06.1
Hughes milk station, 1 mile east of, four corners, 40 feet north to post, 40 feet south to post	38	28	54.8	85	39	03.5
Hughes milk station, 1.25 miles east of, four corners, 560 feet northeast of, stone set at west edge of road, carved on top "N R' and on east face "139"	38	28	58.0	85	38	57.8
Greens Mill, 1.25 miles northwest of, three corners, public T road east, stone planted	38	29	19.6	85	38	19.8
Greens Mill, three corners, T road west up hill, 50 feet east to ice house, 30 feet west to sycamore	38	28	52.4	85	37	35.0
Runyan, store and post-office, 300 feet northeast of, at west edge of main road at second-class road to west and bend of main road to east, iron post stamped "Prim. Trav. Sta. No. 3, 1905"	38	29	21.4	85	36	29.0
Runyan, 1.5 miles northeast of, three corners, T road to southeast, 40 feet south to elm, 30 feet northwest to sweet gum	38	30	17.2	85	35	09.8
Vesta post-office, 2.1 miles northwest of, four corners, 20 feet south to corner post of wire fence, 40 feet west to corner of garden	38	30	41.6	85	34	30.8
Vesta post-office, 1 mile northwest of, four corners, intersection of secs. 103, 104, 123, and 124, Owens Township, stone planted	38	29	50.2	85	33	43.0
Vesta post-office, four corners, 25 feet north to corner of wire fence, 25 feet west to telephone pole	38	29	06.6	85	33	02.4
Solon post-office, well at four corners	38	30	06.1	85	31	32.8
Solon post-office, 0.9 mile southeast of, forks of public roads southeast and east, 30 feet south to corner of fence, 20 feet north to locust	38	29	26.6	85	30	56.1
Bull Creek, center of covered bridge over	38	29	22.7	85	30	06.3
Bull Creek, bridge, 0.6 mile southeast of, T road south, 40 feet southeast to locust, 60 feet west to sycamore	38	29	01.8	85	29	32.8
Westport, Ky., station 577 M+3200 feet, Ohio River survey, United States Army engineers	38	29	00.0	85	28	42.4

NEW ALBANY AND RIVERVIEW QUADRANGLES (FLOYD AND HARRISON COUNTIES, IND.; BULLITT AND JEFFERSON COUNTIES, KY.).

The following geographic positions on the United States standard datum were obtained by primary traverse run in 1905 by C. B. Kendall, field assistant. The line starts with an adjusted position at Jeffersonville and follows the Pennsylvania Interurban Railroad to New Albany, thence west along the Southern Railway to a point 1.6 miles west of Georgetown, where the line turns south and follows public highways along the west border of the Riverview quadrangle and is tied to a primary-traverse position at West Point.

New Albany Quadrangle (Floyd County, Ind.).

Geographic positions along Pennsylvania Interurban Railroad.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Jeffersonville, crossing Baltimore and Ohio Southwestern and Pennsylvania Interurban R. Rs., center of tracks	38	16	26.6	85	44	52.6
Jeffersonville, Beckett street crossing, center of tracks	38	16	38.8	85	45	27.3
New Albany, Baltimore and Ohio Southwestern R. R. station, 1.1 miles east of, road crossing, north rail of south track	38	17	41.6	85	47	06.[illegible]
New Albany, near Baltimore and Ohio Southwestern Rwy. station, center of railroad intersection of Main and Vincennes streets	38	17	21.9	85	48	16.1
New Albany, at end of Pennsylvania Interurban R. R., State street crossing, center of north main track	38	16	57.0	85	49	21.4

Geographic positions along Southern Railway.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
New Albany, at west edge of, Budd road crossing, center of track	38	16	23.9	85	50	29.4
New Albany, Southern Rwy. station, 2 miles west of, road crossing, center of track	38	16	38.9	85	51	17.[illegible]
Duncan Hill tunnel, 1.6 miles southeast of, pike crossing, center of track	38	17	04.6	85	52	32.[illegible]
Duncan Hill tunnel, 0.4 mile southeast of, pike crossing, center of track	38	17	11.4	85	53	47.6
Duncan station, 0.25 mile southwest of, Duncan post-office and store of J. B. Nichols, at southeast corner of store, on north edge of Edwardsville-Georgetown pike and 300 feet south of center of main track of Southern Rwy., iron post stamped "Prim. Trav. Sta. No. 4, 1905"	38	17	12.9	85	55	27.9
Duncan post-office, 100 feet east of, public-land survey corner, 229 feet south of Southern Rwy	38	17	13.5	85	55	27.6
Georgetown station, 1.6 miles southeast of, pike crossing, center of track	38	17	34.3	85	56	45.[illegible]
Georgetown station, 680 feet east of, street crossing, center of track	38	17	36.9	85	58	21.[illegible]
Georgetown station, 1.6 miles west of, road crossing, center of track	38	17	12.3	85	59	55.2

Geographic positions along highways.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Georgetown, about 1.25 miles west of, T road south	38	17	06.1	85	59	32.9
Georgetown, 1.25 miles west of, 0.2 mile south of Southern Rwy., T road south on T. 3 S., R. 5 E., north-south county and section line between secs. 5 and 6, in southeast corner of junction, iron post stamped "Prim. Trav. Sta. No. 5, 1905"	38	17	05.9	85	59	32.6
T. 3 S., R. 5 E., corner secs. 5, 6, 7, and 8, stone at bend of road to west	38	16	21.6	85	59	33.0
Three corners, public T road to south, stone on north edge of road	38	16	21.7	86	00	06.7
Four corners, crossing of Georgetown-Lanesville road and New Albany-Corydon old stage road, 20 feet northwest to corner shop, 60 feet southeast to walnut tree	38	15	40.4	86	00	06.9

Riverview Quadrangle (Harrison County, Ind.; Bullitt and Jefferson counties, Ky.).

Geographic positions along Louisville and Nashville Railroad between Louisville and Highland Park (Kentucky).

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Louisville, Oak street crossing Louisville and Nashville R. R.	38	14	07.4	85	46	06.2
Louisville, crossing of Louisville and Nashville R. R. and Southern Rwy., Park avenue, west track	38	12	52.6	85	45	50.2
South Louisville, station	38	11	58.1	85	45	35.6
Highland Park, station	38	11	15.2	85	45	24.0
Highland Park, road crossing 1 mile south of	38	10	33.5	85	45	12.9

Geographic positions along highways from Shepherdsville to Riverview, in Kentucky.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Shepherdsville, road northwest 1.25 miles west of, 68 feet southwest to cross on pine tree, 42 feet northeast to cross on post-oak tree	37	59	54.0	85	44	16.0
Bullitts Lick, crossroads, 33 feet north to cross on corner fence post, 42 feet east to cross on board fence	38	00	05.9	85	45	18.0
Crossroads, at store and blacksmith shop, 70 feet southwest to front gate to church, 36 feet north to post with horseshoe nails in it	38	00	02.8	85	45	52.7
Forks of rood, at southeast corner of J. T. Martin's orchard, 25 feet to cross on small pine tree, 36 feet north to cross on telephone pole	38	00	24.3	85	46	55.9
Miller (George) house, arrow painted on gatepost at entrance to lane	38	01	33.8	85	48	26.9
Barrallton, 1.5 miles southwest of, in yard to R. D. Snellen's residence; southeast corner of house bears N. 75° 15′ W., distant 121.5 feet; nail in blaze on south face of sycamore tree 30 inches in diameter bears N. 42° 10′ E., distant 130.8 feet; iron post stamped "Prim. Trav. Sta. No. 33"	38	01	38.6	85	49	12.1
Miller (Harden) farm, arrow on gatepost to entrance	38	01	09.2	85	50	42.7
Moore's store, T road south, 18 feet south to northwest corner of porch to store, 32 feet north to cross on gatepost	38	00	28.2	85	51	36.2
Cupio, center of small bridge 0.25 mile northeast of, at road southwest.	38	00	31.2	85	52	29.1
Griffin (John) residence, cross on telephone pole on south side of road.	38	01	00.1	85	53	38.9
Road crossing, under trestle to new railroad	38	00	59.4	85	54	17.6

Geographic positions along Louisville and Nashville Railroad, Riverview to West Point (Kentucky).

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Riverview, road crossing	38	01	28.4	85	54	57.6
Riverview, private road crossing 1 mile south of	38	00	45.5	85	55	38.5
West Point, in northwest corner of public school grounds, northwest corner of brick foundation to schoolhouse bears S. 27° 10′ E., distant 26.9 feet; southwest corner of stone foundation to Christian Church bears N. 13° 35′ E., distant 13.6 feet; iron post stamped "Prim. Trav. Sta. No. 34"	37	59	52.7	85	56	58.8
West Point, center of crossing of Bach and Carter streets	37	59	55.5	85	56	47.4

Geographic positions along highways (Indiana).

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Lanesville, 1.3 miles north of, forks second-class road to southeast, 40 feet east to oak tree at gate	38	14	52.2	85	59	44.9
Lanesville, 0.8 mile north of, iron gas pipe driven in ground at bend of road to south, 250 feet southeast of ford of small creek	38	14	35.9	85	59	33.3
Lanesville, crossing of New Albany-Corydon pike (main street), and Georgetown-Black Creek road, 25 feet southwest to northeast corner of Jacob Facfingor's store, 30 feet southeast to maple tree at corner	38	14	14.2	85	59	09.8
Lanesville, 1.2 miles south of, at top of hill, forks, public roads southwest and southeast, 20 feet west to walnut, 60 feet south to old stump	38	13	03.8	85	59	03.7
Fellow schoolhouse, three corners at, public T road to west, 20 feet northwest to corner wire fence, 50 feet south to corner schoolhouse	38	11	57.5	85	58	52.8
Buck Creek ford, 300 feet north of, forks, roads north and northeast, 20 feet north to maple, 50 feet south to maple	38	11	04.5	85	56	35.9
Black Creek post-office, 300 feet east of, at foot of hill, forks of roads southeast and west	38	10	41.7	85	58	40.3
Kerr schoolhouse, No. 3, Posey Township, four corners, 30 feet south to gate, 40 feet northeast to telephone pole	38	10	13.6	85	58	27.2
Kerr schoolhouse, 0.6 mile south of, stone at three corners, second-class T road to west	38	09	48.9	85	58	35.8
Elizabeth, 2.2 miles north of, forks at top of hill, second-class road to northeast, 25 feet north to telephone pole	38	08	47.2	85	58	36.0
Elizabeth, 0.5 mile northwest of, three corners, T road north, 30 feet east to locust, 30 feet north to locust	38	07	36.7	85	58	36.9
Elizabeth, street crossing 250 feet east of public school building, center of intersection	38	07	15.4	85	58	27.0
Elizabeth, 250 feet west of Main street crossing, at southeast corner of public school, iron post stamped "Prim. Trav. Sta. No. 6, 1905"	38	07	15.8	85	58	30.1
Elizabeth, 1 mile south of, large oak at three-corner public T road to west	38	06	22.9	85	58	34.4
T. 5 S., R. 5 E., corner secs. 8, 9, 16, and 17, also east-west township line between Posey and Taylor townships (civil), corner is stone in center of road 200 feet south of three-corner public T road to west	38	04	56.6	85	58	34.4
Convenience, 1 mile north of, forks of public roads south and west, 60 feet south to maple, 20 feet west to rail fence	38	04	14.8	85	58	25.3
Convenience, Catholic Church, 200 feet west of, four corners, public crossroads, 40 feet south to corner garden, 100 feet east to oak	38	03	30.7	85	58	47.8
Convenience, 1.2 miles south of, three corners, second-class T road west, two mail boxes	38	02	35.7	85	58	51.5
Convenience, 1.7 miles south of, Rosehill schoolhouse, 1,150 feet northeast of, stone planted in center of road	38	02	18.1	85	59	02.6
Rosehill schoolhouse, 1 mile southwest of, forks of public roads northeast and north, 10 feet south to mail box, 35 feet north to mail box	38	01	35.7	85	59	35.7
Evans Landing post-office, 0.6 mile west of, forks, public roads northwest and west, center of triangle at forks	38	00	27.8	85	59	35.0
Evans Landing post-office, small stream, center of iron bridge over	38	00	11.6	85	59	04.3
Evans Landing post-office, 1.1 miles northeast of, three corners, second-class road to south, 50 feet west of barn	38	00	25.6	85	56	01.8

KENTUCKY.

PRIMARY TRAVERSE.

CALDWELL, CRITTENDEN, HOPKINS, AND WEBSTER COUNTIES.

CLAY QUADRANGLE.

The line starts from primary traverse station No. 10, 1904, at Sullivan, Ky., follows the Illinois Central Railroad to Repton, thence southerly along highways through Tribune and Starr to Enon, thence easterly over county roads through Creswell to Dalton, thence north over highways to Providence, thence to Lisman railroad station, connecting with road crossing at that place; located by primary traverse in 1904. The field work was done by J. R. Ellis in 1906.

Magnetic declination, east border, 3° 47′ east; south border, 4° 13′ east; west border, 4° 27′ east.

Geographic positions along Illinois Central Railroad, Sullivan to Repton.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Sullivan, primary traverse station No. 10, 1904	37	29	58.8	87	56	37.1
Sullivan, road crossing 0.75 mile southeast	37	29	21.5	87	56	14.4
Road crossing under trestle at milepost 60	37	28	03.9	87	55	47.8
Blackford railroad station, road crossing	37	27	02.6	87	56	04.1
Blackford, 1.25 miles south of, road crossing north and south	37	26	15.9	87	56	59.1
Gladstone post-office, road crossing	37	25	46.6	87	58	06.0
Hood siding, road crossing at south end of	37	25	23.2	88	00	03.2
Road crossing 150 feet north of milepost 62	37	24	22.0	88	00	34.0
Repton, railroad station	37	23	24.8	88	00	56.0
Repton and Tribune, crossroads half way between, in northwest corner of R. Newcomb's farm, nail in blaze on walnut tree bears S. 81° 45′ E., distant 112.9 feet; nail in blaze on small oak bears S. 89° W., distant 34 feet; iron post stamped "Prim. Trav. Sta. No. 15, 1906"	37	22	35.1	87	59	48.1

Geographic positions along highways from Repton through Tribune and Starr to Enon, thence easterly over county roads through Creswell to Dalton.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Crossroads on top of hill, 15 feet west to blaze on black oak, 33 feet east to blaze on sapling	37	21	37.9	87	59	38.8
Tribune, crossroads, 16 feet northwest to store, northeast corner, 24 feet northeast to corner of coal house	37	20	56.8	87	59	26.0
Widow Brantley's residence, crossroads, 16 feet northwest to walnut tree, 38 feet north to mulberry tree	37	19	55.4	87	59	37.0
Wilsons Creek, 0.66 mile south of, T road southeast, 15 feet east to corner fence post, 22 feet southeast to corner orchard fence	37	18	53.2	88	00	22.4
Starr, crossroads, 32 feet east to Brucher's mail box, 21 feet southeast to west corner of shed to blacksmith shop	37	17	36.0	88	00	10.2
Crittenden-Caldwell county line stone, center of road opposite, 18 feet southwest to stone	37	16	21.8	88	59	31.0
Enon, Walnut Grove Church, at corner of old Polk farm at T. lane northeast, about 0.75 mile northeast of Enon, nail in small black oak bears S. 79° 25′ E., distant 13.3 feet; T road northeast bears S. 28° 30′ E., distant 35 feet; iron post stamped "Prim. Trav. Sta. No. 16, 1906"	37	15	34.1	87	58	43.9
Oliver (L. L.) residence, at road northwest, arrow painted on tree	37	15	56.5	87	57	40.6
HowRidge schoolhouse, forks of road, 19 feet south to W. R. Briggs's mail box, 27 feet northwest to cross on elm tree	37	16	32.7	87	57	19.5
Forks of road, arrow cut on black-oak tree	37	16	19.4	87	55	30.2
Creswell, forks of road, 18 feet northwest to J. T. Brown's mail box, 20 feet southwest to arrow on rail fence	37	16	13.3	87	54	40.6
T lane northwest	37	16	25.2	87	53	29.4
Junction of branches at point where road crosses	37	16	54.8	87	52	44.1
Walnut Hill school grounds, southeast corner of foundation to schoolhouse bears N. 85° W., distant 18.6 feet; nail in blaze on east face of walnut tree bears S. 28° 45′ W., distant 23.5 feet; iron post stamped "Prim. Trav. Sta. No. 17, 1906"	37	17	11.4	87	52	09.2
J. N. Castleberg's barn, forks of road, 31 feet northeast to stump, 24 feet east to southwest corner of barn	37	17	28.3	87	51	19.7
Quinn, T road south at blacksmith's shop, 18 feet southwest to northeast corner of shop, 58 feet east to hickory tree	37	17	43.6	87	50	07.9
Quinn, forks of road about 1 mile east of, 22 feet southeast to mulberry tree, 24 feet north to west end of bridge	37	17	40.0	87	48	56.8
Caldwell-Hopkins county line, center of Tradewater river	37	18	00.4	87	48	25.8
Crossroads, stump	37	17	56.7	87	46	39.5
Dalton, in front of public school, 3 feet from school building, iron post stamped "Prim. Trav. Sta. No. 18, 1906"	37	17	49.7	87	45	55.6

Geographic positions north along highways to Providence, thence to Lisman railroad station, connecting with road crossing at that place, located by primary traverse of 1904.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Dalton, T road 0.5 mile north of, 21 feet northwest to cross on post, 27 feet northeast to end of picket fence	37	18	28.2	87	45	31.0
Dalton, T road 1.5 miles north of, 19 feet southeast to gum tree, 35 feet southwest to cross on rail fence	37	19	38.1	87	45	13.1
Stony Ridge Church, T road west 0.33 mile north, 28 feet northwest to corner fence post, 21 feet northeast to telephone pole	37	20	18.0	87	45	29.6
Providence, T road south about 3.5 miles south of, 24 feet southeast to corner fence, 45 feet southwest to elm tree	37	21	52.3	87	44	55.5
Hopkins-Webster county line, bridge	37	23	04.3	87	44	53.5
Providence, in retaining wall of T. B. Paine's front yard, aluminum tablet stamped "Prim. Trav. Sta. No. 19, 1906"	37	23	57.9	87	45	41.5
Road east and west under bridge	37	24	51.0	87	45	25.8
Crab Orchard Creek, T road west 0.75 mile south of, 25 feet northwest to corner of rail fence, 18 feet southwest to corner fence post	37	26	01.5	87	45	10.6
Road southeast, 6 feet west to stump, 27 feet southwest to south end of bridge	37	26	56.0	87	44	40.4
Lisman railroad station, road crossing 120 feet west of	37	28	13.5	87	43	45.3

JEFFERSON COUNTY.

LOUISVILLE CITY SURVEY.

In the spring of 1906 J. R. Ellis, assistant topographer, was detailed to the commissioners of sewerage of the city of Louisville, for the purpose of extending lines of primary control throughout the city. The area of the city was divided into 12 rectangular blocks approximately 1.5 by 2 miles, around the borders of which lines of primary traverse were run. Particular care was taken to have the work done accurately, the deflection angles being measured four times, and distances being measured twice with a steel tape under a constant tension, the temperature also being noted. At intervals of 2,000 feet along the route of traverse a permanent station mark, consisting of a bronze tablet 3.5 inches in diameter, was countersunk and cemented into the top of a stone post 3 feet in length, dressed 6 inches square on top, set in the ground flush with surface.

Positions are given on the United States standard datum and are based on North Base and Blind Asylum triangulation stations of the United States Coast and Geodetic Survey.

Geographic positions at Louisville.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Louisville north base triangulation station, on the land of Joseph Lee. The station is situated in the field lying immediately south of the place of Mr. Murray, who knows the location of the station; so does Mr. Beutel, who rents Mr. Lee's place. The station is in an open, cultivated field with no trees near it. Station mark: An earthenware pyramid base 6 by 6 inches, height 5 inches, placed 3 feet 7 inches below surface as underground mark. The apex of the pyramid marks the exact center of the station. The letters U. S. C. S. are cut in the face of the pyramid. Above this was placed a granite post 4 feet 10 inches long, rough at bottom and drest to 10 inches at top, the south side of which the following is cut: U. S. C. & G. S. North Base 1879 The top of the post is in the form of a pyramid, in the apex of which a copper bolt was driven in a hole drilled in the post, and the intersection of the rectangular cross lines cut in the top of the bolt marks center of station. Reference marks: Three other stones, 2 feet 6 inches long, rough at bottom and drest to 4 by 4 inches at the top, were used as additional surface marks, one in prolongation of base line to the north of the station, one on the base line to the south of the station, and the other at right angles to this line to the east of the station. Each of these posts has cross lines cut in the top, with an arrow pointing to the station. The intersection of these cross lines in each case is 6 feet distant from the center of the station. The center post projects 1 foot 6 inches above ground, the others 4 inches.	38	13	27.84	85	49	47.29
B. M. 1, on south side of Bell's lane 3 feet north of east-west fence, nail in blaze of tree, azimuth 174°, distance 173.8 feet; gatepost, azimuth 3° 03′, distance 62.1 feet	38	13	22.02	85	49	34.37
B. M. 2, in top of bank on south side of road in Bell's lane, 1,100 feet west of Cane Run road, Louis Plochner's house, azimuth 242° 27′, distance 144.1 feet; tree, azimuth 212° 16′, distance 46.6 feet	38	13	17.41	85	49	06.11
B. M. 3, on east side of Cane Run road, 820 feet northeast of Bell's lane, 9 feet west of fence, 41.7 feet southwest to nail in telephone pole, 37.4 feet south to cross on north end of stone culvert, nail in telephone pole, azimuth 112° 18′, distance 41.7 feet	38	13	20.97	85	48	38.77
B. M. 4, at intersection of Cane Run road and Beech street, pump, azimuth 113° 32′, distance 19.5 feet; Cramer's saloon, azimuth 177° 49′, distance 26.5 feet	38	13	40.54	85	48	20.54
B. M. 5, at northwest corner of Beech street and Woodward avenue, gas pipe on corner, azimuth 280° 07′, distance 50.6 feet; house, azimuth 117° 32′, distance 39 feet	38	14	02.91	85	48	17.68
B. M. 6, at southwest corner of Danesville and Amber streets at foot of Twenty-eighth street; drug store azimuth 139° 00′, distance 80.2 feet; corner of store, azimuth 205° 26′, distance 43.3 feet	38	14	10.83	85	48	01.82
B. M. 7, at northeast corner of Twenty-eighth and Kentucky streets, northwest corner grocery store, azimuth 1° 53′, distance 62.1 feet; corner bakery, azimuth 212° 12′, distance 20 feet	38	14	35.89	85	47	57.40
B. M. 8, at southeast corner of Twenty-eighth street and Broadway, corner of post-office station H, azimuth 192° 13′, distance 85.6 feet; northwest corner of curb, azimuth 144° 04′, distance 61.8 feet	38	14	56.89	85	47	53.69
B. M. 9, at southeast corner of Twenty-eighth and Madison streets, grocery store, azimuth 310° 29′, distance 7 feet; corner residence No. 1600, azimuth 91° 36′, distance 60.9 feet	38	15	14.43	85	47	50.60
B. M. 10, on north side of Market street at head of Twenty-eighth street; grocery store, azimuth 355° 22′, distance 66.9 feet; corner of saloon, azimuth 52° 04′, distance 79.1 feet	38	15	34.26	85	47	47.22
B. M. 11, at northeast corner of Twenty-sixth and Rowan streets, corner of saloon, azimuth 227° 00′, distance 9.1 feet; south end of fence, azimuth 135° 22′, distance 61.9 feet	38	15	42.43	85	47	36.13
B. M. 12, at northeast corner of Twenty-sixth and Slevin streets, corner of Ohlman's exchange, azimuth 100° 28′, distance 47 feet; Hochstrass azimuth 258° 28′, distance 9.8 feet	38	15	55.83	85	47	34.62
B. M. 13, at southeast corner of Twenty-sixth street and Portland avenue, grocery store, azimuth 108° 09′, distance 46.6 feet; Struby's pump, azimuth 352° 46′, distance 7.9 feet	38	16	14.26	85	47	23.93
B. M. 14, on Portland avenue, 65 feet west of west curb to Thirtieth street, and 8 feet east of center of Kentucky and Indiana Bridge R. R.	38	16	22.60	85	47	47.27
B. M. 15, at northwest corner of Thirty-third and Rudd streets, grocery store, azimuth 136° 45′, distance 9.3 feet; pump, azimuth 260° 08′, distance 81.5 feet	38	16	34.11	85	48	04.77
B. M. 16, at southeast corner of Thirty-fifth and Water streets, corner of saloon, azimuth 317° 50′, distance 15.5 feet; manhole in Water street, azimuth 199° 03′, distance 10.7 feet	38	16	42.91	85	48	17.85
B. M. 17, at southwest corner of Thirty-fifth and High streets, south corner of wall of academy grounds, azimuth 130° 15′, distance 129 feet; cement foundation, azimuth 55° 48′, distance 13.7 feet	38	16	27.26	85	48	16.03
B. M. 18, on south side of High street, 446 feet west of west curb to Thirty-eighth street, corner of brick house, azimuth 191° 33′, distance 91.9 feet; corner of warehouse, azimuth 132° 03′, distance 131 feet	38	16	25.53	85	48	41.84

Geographic positions at Louisville—Continued.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
B. M. 19, on south side of Bark street extended and on north side of Mrs. Annie Findlay's farm, 300 feet from Ohio River, nail in sycamore tree, azimuth 267° 40′, distance 59.5 feet; nail in tree, azimuth 132° 27′, distance 73.4 feet	38	16	22.75	85	49	23.34
B. M. 20, at southwest corner of Fountain Ferry road and boulevard at northwest corner of Fountain Ferry Park, nail in pole azimuth, 295° 26′; nail in tree, azimuth 258° 56′	38	15	53.13	85	49	33.09
B. M. 21, at junction of east-west road and road north in west part of Shawnee Park, water plug azimuth, 47° 35′, distance 46 feet; lamppost, azimuth 324° 28′, distance 4.5 feet	38	15	29.25	85	49	46.42
B. M. 22, on West Broadway, nail in tree, azimuth 120° 09′, distance 72.8 feet; urn, azimuth 303° 55′, distance 174 feet	38	15	01.34	85	49	50.25
B. M. 23, on Broadway at head of Forty-second street, telephone pole, azimuth 314° 44′, distance 71 feet; telephone pole, azimuth 48° 28′, distance 76 feet	38	15	00.30	85	49	19.70
B. M. 24, on northeast corner of Broadway and Thirty-seventh street, corner of red brick house, azimuth 220° 49′, distance 47.9 feet; southeast corner of yellow brick house azimuth 104° 31′, distance 188.5 feet.	38	14	59.35	85	48	51.64
B. M. 25, on north side of Broadway at Thirty-second street south, corner of church, azimuth 317° 47′, distance 164.9 feet, post, azimuth 19° 45′, distance 81.5 feet	38	14	58.30	85	48	20.76
B. M. 26, on south side of Greenwood avenue and just east of Spring Bank Electric Rwy. station, nail in cherry tree, azimuth 87° 07′, distance 18.3 feet; nail in gum tree, azimuth 205° 46′, distance 64.5 feet.	38	14	41.00	85	49	54.53
B. M. 27, on Dr. B. A. Garr's farm, in northeast corner of barn lot, corner house, azimuth 203° 28′, distance 77.4 feet	38	14	21.50	85	49	57.96
B. M. 28, on south side of Gibson's lane, just east of Little Paddys Run, nail in sycamore tree, azimuth 146° 24′, distance 75.5 feet; nail in cherry tree, azimuth 260° 13′, distance 81.7 feet	38	13	56.72	85	49	47.16
B. M. 29, on south bank of Little Paddys Run, about 400 feet southwest of house rented by Frank Meyers	38	13	41.77	85	50	09.89
B. M. 30, in Bell's lane about 300 feet east of bank of Ohio River, 4 feet north of fence, nail in walnut tree, azimuth 272° 12′, distance 203.1 feet; tree, azimuth 75° 52′, distance 46.2 feet	38	13	23.91	85	50	34.80
B. M. 31, on north side of Bell's lane, just east of entrance to Christ Gilchrist's farm, corner of his house, azimuth 168° 13′, distance 101.2 feet; nail in gum tree, azimuth 62° 27′, distance 82.1 feet	38	13	22.99	85	49	56.91
B. M. 32, on east side of Cane Run road, just north of Woodlawn avenue, nail in tree, azimuth 81° 59′, distance 107.6 feet; southeast corner of house, azimuth 121° 38′, distance 52.7 feet	38	14	00.46	85	47	50.02
B. M. 33, on east side of Eighteenth street at Ormsby avenue west; water plug, azimuth 27° 53′, distance 21.8 feet; southeast corner of saloon, azimuth 125° 52′, distance 57.5 feet	38	14	03.65	85	47	16.21
B. M. 34, on southeast corner of Sixteenth street and Ormsby avenue, center of manhole, azimuth 206° 02′, distance 5.2 feet; southeast corner of house No. 1545, azimuth 147° 43′, distance 99.5 feet	38	14	03.27	85	46	50.29
B. M. 35, on southeast corner of Twelfth street and Ormsby avenue, northeast corner of house, azimuth 83° 52′, distance 56.3 feet; southwest corner of box factory, azimuth 190° 52′, distance 67.6 feet	38	14	01.05	85	46	26.56
B. M. 36, on southeast corner of Seventh street and Ormsby avenue, water plug, azimuth 249° 59′, distance 22.9 feet; northeast corner of Kentucky Heating Co.'s porch, azimuth 48° 51′, distance 62.5 feet	38	13	58.32	85	45	56.73
B. M. 37, on southwest corner of Third street and Ormsby avenue, corner fence post, azimuth 169° 54′, distance 69.9 feet; north point of gate post at No. 1400, azimuth 46° 08′, distance 38.2 feet	38	13	56.21	85	45	33.09
B. M. 38, northeast corner Ormsby avenue and Preston street, southeast corner McGee's drug store, azimuth 155° 23′, distance 101.9 feet; northwest corner store building southeast corner Ormsby avenue and Preston street, azimuth 2° 29′, distance 54.6 feet	38	13	50.49	85	44	39.78
B. M. 39, northwest corner Ormsby avenue and Shelby street, southwest corner of Kentucky Refining Co.'s office, azimuth 211° 15′; northeast corner of car barn, azimuth 12° 05′, distance 56.5 feet	38	13	47.58	85	44	31.02
B. M. 40, west side of Shelby street, opposite St. Catherine street east, southwest corner of residence No. 1741, azimuth 248° 28′, distance 77.9 feet; center of pump, azimuth 324° 42′, distance 64 feet	38	14	06.07	85	44	28.47
B. M. 41, northwest corner Breckenridge and Shelby streets, southwest corner of drug store, azimuth 272° 10′, distance 54.4 feet; southeast corner of grocery store and saloon, azimuth 137° 16′, distance 7.4 feet.	38	14	22.62	85	44	25.62
B. M. 42, northwest corner of Broadway and Shelby avenue, southeast corner of saloon, azimuth 168° 46′, distance 15.8 feet; southwest corner of Neider Bros.' grocery store, azimuth 259° 46′, distance 42.5 feet.	38	14	40.03	85	44	22.63
B. M. 43, northwest corner Shelby and Green streets, southeast corner of Scott's hardware store, azimuth 135° 47′, distance 6.9 feet; southwest corner of Herman's saloon, azimuth 273° 37′, distance 53.3 feet.	38	15	00.62	85	44	19.08
B. M. 44, northwest corner Main and Shelby streets, southwest corner of Methodist Church corner stone, azimuth 261° 32′, distance 60.3 feet; southeast corner of roofing store, azimuth 140° 07′, distance 6.4 feet.	38	15	15.58	85	44	16.47
B. M. 45, north corner of Story avenue and Louisville and Nashville R. R. crossing, north corner of post-office, station A, azimuth 7° 29′, distance 75 feet; south corner National Leather Co.'s building, azimuth 189° 57′, distance 7.8 feet	38	15	18.77	85	43	45.09

Geographic positions at Louisville—Continued.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
B. M. 46, north side of Story avenue and Frankfort avenue southeast, northwest corner of grocery store, azimuth 300° 17′, distance 62.9 feet; corner of saloon, azimuth 226° 48′, distance 12.9 feet	38	15	30.71	85	43	17.64
B. M. 47, west corner of Frankfort avenue and Haldeman street north, northeast corner of store, azimuth 53° 18′, distance 86.6 feet; corner post to B. I. grounds, azimuth 137° 08′, distance 10.7 feet	38	15	18.90	85	42	46.00
B. M. 48, southwest corner of Frankfort avenue and Keats street south, water plug, azimuth 105° 20′, distance 5.9 feet; northwest corner of house, azimuth 272° 15′, distance 30.2 feet	38	15	10.95	85	42	07.29
B. M. 49, southeast corner Frankfort avenue and Park avenue south, corner Crescent Hill Pharmacy, azimuth 74° 24′, distance 55.8 feet; corner Crescent Drug Co., azimuth 327° 07′, distance 8.6 feet	38	15	15.25	85	41	34.47
B. M. 50, south side Frankfort avenue, north of wall to waterworks, water tank nearest corner, azimuth 57° 18′, distance 42.5 feet; corner of stone wall at waterworks, azimuth 348° 28′, distance 7 feet	38	15	14.75	85	40	57.28
B. M. 51, northwest corner of crossing of Brownsboro road and Pipe Line avenue, north corner of westernmost gate post to entrance to reservoir grounds, azimuth 332° 02′, distance 68.8 feet; center of water plug, azimuth 299° 09′, distance 48.2 feet	38	15	38.87	85	41	03.75
B. M. 52, west side of Pipe Line avenue or cinder road 3,750 feet south of Prospect Electric R. R. and 950 feet north of T road east; nail in locust tree, azimuth 18° 37′, distance 21.8 feet; nail in locust tree, azimuth 126° 06′, distance 26.7 feet	38	15	52.37	85	41	21.81
B. M. 53, west side of Pipe Line avenue or cinder road just north of Prospect Electric R. R., tree, azimuth 217° 45′, distance 28.7 feet; tree, azimuth 86° 22′, distance 22.1 feet	38	16	23.97	85	41	46.82
B. M. 54, south side of River road about 600 feet west of entrance to golf links, nail in tree, azimuth 78° 32′, distance 92.6 feet; nail in hollow tree, azimuth 154° 12′, distance 40 feet	38	16	30.93	85	42	06.65
B. M. 55, south side of River road opposite G. Hooper's residence, iron pump, azimuth 125° 20′, distance 55 feet; north corner of brick house, azimuth 356° 59′, distance 58.6 feet	38	16	16.59	85	42	31.21
B. M. 56, east side of River road 678 feet northeast of Louisville and Nashville R. R., nail in telephone pole, azimuth 94° 55′, distance 69.4 feet; north corner of house, azimuth 15° 50′, distance 64.1 feet	38	16	03.59	85	43	00.24
B. M. 57, north corner Van Buren and Marion streets, east corner of house, azimuth 82° 54′, distance 60.3 feet; center of pump, azimuth 23° 33′, distance 58.8 feet	38	15	55.69	85	43	24.64
B. M. 58, north corner Fulton and Adams streets, corner of saloon and grocery, azimuth 337° 11′, distance 11.9 feet; northwest corner of sawmill office, azimuth 205° 08′, distance 68.8 feet	38	15	48.27	85	43	49.17
B. M. 59, northeast corner Fulton and Shelton streets, center of fire plug, distance 61.1 feet; center of westernmost boiler, distance 42.5 feet	38	15	36.24	85	44	21.41
Story street crossing of Louisville and Nashville R. R. (Ellis, 1904)	38	15	18.43	85	43	45.03
B. M. 60, southwest corner of Seventh and Shipp streets, center of pump, azimuth 121° 33′, distance 6.4 feet; northwest corner of saloon, azimuth 336° 20′, distance 5.5 feet	38	13	32.85	85	46	09.39
B. M. 61, west side of Seventh street road about 720 feet south of Southern Rwy., nail in small tree, azimuth 64° 42′, distance 48.9 feet; nail in telephone pole, azimuth 353° 24′, distance 54.1 feet	38	13	19.50	85	46	26.21
B. M. 62, on west side of Seventh street road, 680 feet south of Thompson's road, northeast corner of Jacob Schafflin's residence, azimuth 57° 17′, distance 97.1 feet; nail in telephone pole, azimuth 259° 14′, distance 67.6 feet	38	13	05.72	85	46	44.69
B. M. 63, west side of Seventh street road, at Arcade avenue southeast, northeast corner of brick dwelling, azimuth 132° 01′, distance 65.9 feet; southwest corner of G. J. Schmidt's saloon and grocery, azmuth 316° 33′, distance 63 feet	38	12	33.56	85	47	13.71
B. M. 64, on west side of Sand River road opposite entrance to Bohemian farm, nail in telephone pole, azimuth 171° 34′, distance 30.4 feet; nail in large beech tree, azimuth 266° 33′, distance 79.1 feet	38	12	34.57	85	47	52.61
B. M. 65, on east side of Eighteenth street or Sand River road, at schoolhouse lane west, center of stone post at corner of schoolhouse lane, azimuth 108° 31′, distance 47.2 feet; southwest corner of schoolhouse, azimuth 254° 04′, distance 80.7 feet	38	12	51.66	85	47	45.27
B. M. 66, on south side of schoolhouse lane just west of entrance to W. T. Hartledge's farm, nail in west gate post of Hartledge road, azimuth 276° 46′, distance 54.4 feet; nail in pear tree, azimuth 33° 25′, distance 5.3 feet	38	12	53.49	85	48	14.52
B. M. 67, on west side of road 0.33 mile south of intersection of Cane Run road and Bell's lane, nail in gate post south side of schoolhouse lane, azimuth 324° 36′, distance 22 feet	38	12	56.94	85	48	46.73
B. M. 68, on east side of Taylor boulevard at Arcade avenue northwest, south corner of house, azimuth 164° 16′, distance 119.6 feet	38	12	06.07	85	46	53.36
B. M. 69, on Taylor boulevard at junction with Berry boulevard, southeast corner of saloon, azimuth 123° 10′, distance 98 feet; northeast corner of blacksmith shop, azimuth 64° 55′, distance 108.4 feet	38	11	45.42	85	46	58.49
B. M. 70, on east side of Taylor boulevard, at Woodland Grove, southeast corner of grocery store, azimuth 106° 41′, distance 79.2 feet; nail in elm tree, azimuth 265° 19′, distance 79.6 feet	38	11	15.09	85	47	00.76

Geographic positions at Louisville—Continued.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
B. M. 71, on east side of Taylor boulevard, nail in locust tree, azimuth 130° 57′, distance 63.8 feet; nail in small sycamore tree, azimuth 57° 04′, distance 43 feet	38	10	52.77	85	47	00.79
B. M. 72, on west side of Taylor boulevard at Joseph App's house, northeast corner of house, azimuth 61° 16′, distance 94.8 feet; nail in telephone pole, azimuth 351° 54′, distance 10.6 feet	38	10	28.95	85	46	57.78
B. M. 73, on south side of Taylor boulevard, at Third street boulevard northeast, south corner of Boone cabin, azimuth 203° 25′; south corner of arch, azimuth 316° 35′, distance 139.5 feet	38	10	10.06	85	46	53.16
B. M. 74, on west side of parking to Third street, about 2,400 feet northeast of end of boulevard, center of lamp-post, azimuth 39° 06′, distance 56.8 feet; nail in box-elder tree, azimuth 118° 31′ distance, 55.2 feet	38	10	26.86	85	46	30.51
B. M. 75, on west side of parking to Third street, 812 feet south of street-car line, nail in blaze on tree, azimuth 188° 11′, distance 69 feet; center of lamp-post, azimuth 295° 03′, distance 54.7 feet	38	10	47.75	85	46	14.79
B. M. 76, on west side of parking at milepost 1½, northeast corner of porch to residence opposite milepost, azimuth 112° 18′, distance 123.8 feet; center of lamp-post, azimuth 192° 58′, distance 102.4 feet	38	11	08.50	85	46	02.70
B. M. 77, on west side of Third street boulevard at milepost 2, blaze on sycamore tree, azimuth 102° 02′, distance 42.7 feet; center of lamp-post, azimuth 289° 54′, distance 54.7 feet	38	11	34.46	85	46	00.59
B. M. 78, on west side of boulevard, southeast corner of mottled brick residence, azimuth 147° 41′, distance 108.9 feet, center of lamp-post, azimuth 240° 09′, distance 61 feet	38	11	53.65	85	46	01.35
B. M. 79, on west side of Third street, 229 feet south of south curb of P street, nail in poplar tree, azimuth 198° 49′, distance 11.8 feet; Christain Mission, southwest corner of, azimuth 268° 07′, distance 103.4 feet	38	12	14.05	85	45	51.02
B. M. 80, on southwest corner of Third avenue and L street west, southeast corner of Gass's drug store, azimuth 164° 47′, distance 114.1 feet; center of water plug, azimuth 286° 59′, distance 58 feet	38	12	55.02	85	45	47.34
B. M. 81, on north end of Triangle Park, southwest corner of Confederate monument, azimuth 195° 30′, distance 127.8 feet; Louisville reform school, center of tablet, azimuth 243° 19′, distance 89 feet	38	13	05.30	85	45	42.01
B. M. 82, on northwest corner of Third and Hill streets, northeast corner of residence No. 1700, azimuth 59° 49′, distance 80.5 feet; northwest corner of residence No. 1801, azimuth 303° 33′, distance 113.2 feet	38	13	31.89	85	45	37.55
B. M. 83, on southwest corner of Main and Jackson streets, northeast corner of retaining wall to yard, azimuth 43° 40′, distance 13.7 feet; northwest corner of American machine shops, azimuth 290° 14′, distance 52.4 feet	38	15	17.24	85	44	38.32
B. M. 84, on southeast corner of Main and First streets, northeast corner of Bill Dryer Co.'s building, azimuth 93° 34′, distance 53.3 feet; northwest corner of James Thompson & Bros.' liquor store, azimuth 299° 30′, distance 10.2 feet	38	15	20.14	85	45	05.61
B. M. 85, on northwest corner of Main and Seventh streets, northwest corner of post-office station 23, azimuth 340° 03′, distance 105 feet; southwest corner of drug store, azimuth 282°, distance 49.2 feet	38	15	24.98	85	45	41.70
B. M. 86, on northeast corner of Main and Eleventh streets, southeast corner of Doyle's saloon, azimuth 99° 04′, distance 50.1 feet; northeast corner of J. V. Reed & Co.'s store, azimuth 37° 30′, distance 101.6 feet	38	15	27.50	85	46	05.04
B. M. 87, on northeast corner of Main and Fifteenth streets, southeast corner of R. F. Avery & Sons' store, azimuth 109° 11′, distance 52.8 feet; northwest corner of J. B. Gibson's store, azimuth 1° 56′, distance 80.2 feet	38	15	30.08	85	46	28.88
B. M. 88, on northeast corner of Main and Nineteenth streets, pump at southwest corner, azimuth 37° 56′, distance 87.3 feet; saloon at northwest corner, azimuth 100° 53′, distance 50.5 feet	38	15	32.82	85	46	52.66
B. M. 89, on northeast corner of Main and Twenty-fourth streets, dry-goods store, southeast corner, azimuth 108° 56′, distance 53.6 feet; northwest corner of American Tobacco Co.'s warehouse, azimuth 2° 45′, distance 80.2 feet	38	15	36.08	85	47	22.47
B. M. 90, on southeast corner of Preston and Burnett streets, crossing gate Louisville and Nashville R. R., azimuth 91° 31′, distance 42.2 feet; switch block to railroad, azimuth 218° 22′, distance 35.3 feet	38	13	32.58	85	45	02.87
B. M. 91, on south corner of Preston and Vandise streets, United Brethren Church, north corner, azimuth 50° 01′, distance 142.6 feet; R. Nussbaum's saloon, southeast corner, azimuth 135° 29′, distance 52.9 feet	38	13	09.55	85	44	52.82
B. M. 92, on southwest corner of Jackson and F streets, southwest corner of Williams's store, azimuth 220° 04′, distance 105.4 feet; northeast corner of residence No. 536 F street, azimuth 86° 31′, distance 50 feet	38	12	54.21	85	45	03.09
B. M. 93, on east side of Ash Bottom road, 515 feet north of Southern Rwy.; nail in fence post, elevation 483 feet, azimuth 113° 17′, distance 38.7 feet; nail in blaze on west face of locust tree, azimuth 184° 28′, distance 121.9 feet	38	12	33.23	85	45	04.07

Geographic positions at Louisville—Continued.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
B. M. 94, on east side of Ash Bottom road just south of entrance to Henry Harphage's farm, nail in blaze on locust tree, azimuth 79° 19′, distance 46 feet; cross on top of corner stone, azimuth 215° 20′, distance 29.6 feet	38	12	14.14	85	45	02.70
B. M. 95, on east side of Ash Bottom road, just south of bridge, nail in blaze on small tree, azimuth 81° 05′, distance 26.9 feet; southeast corner of foundation to bridge, azimuth 205° 46′, distance 22 feet	38	11	53.96	85	45	03.21
B. M. 96, on west side of Ash Bottom road, small frame house, azimuth 191° 50′, distance 180.2 feet; nail in blaze on wild cherry tree, azimuth 317° 54′, distance 53.7 feet	38	11	30.88	85	45	03.71
B. M. 97, on east side of Ash Bottom road at Wanona avenue, southeast corner of frame house, azimuth 104° 34′, distance 51.8 feet; nail in blaze on water oak tree, azimuth 217° 10′, distance 48.3 feet	38	11	07.78	85	45	01.96
B. M. 98, on sidewalk at southeast corner of Pocahontas avenue and Louisville and Nashville R. R. right of way, southeast corner of retaining wall of culvert abutment, azimuth 76° 51′, distance 38 feet; southwest corner of C. T. Johns's saloon, azimuth 170° 53′, distance 71 feet	38	10	52.39	85	45	16.42
B. M. 99, on north side of Woodlawn street at top of hill, elm tree, nail in blaze, azimuth 143° 32′, distance 18 feet; nail in small cottonwood tree, azimuth 67° 02′, distance 73.7 feet	38	10	50.08	85	45	36.23
B. M. 100, on north side of Phillips lane, about 200 feet southeast of old Phillips house, nail in hackberry tree, azimuth 250° 32′, distance 50.5 feet; nail in apple tree, azimuth 131° 06′, distance 10.3 feet	38	11	35.28	85	44	23.17
B. M. 101, on east side of Preston street road at Phillips lane west, nail in elm tree, azimuth 18° 26′, distance 67.4 feet; nail in locust tree, azimuth 321° 04′, distance 49.9 feet	38	11	50.48	85	43	53.74
B. M. 102, on west side of Preston Street road, at Hess lane northeast, southeast corner of schoolhouse, azimuth 30° 54′, distance 63.4 feet; southeast corner of culvert at junction of Hess lane, azimuth 258° 48′, distance 35.3 feet	38	12	16.48	85	44	10.87
B. M. 103, on east side of Hess lane at Prindell avenue northwest, nail in telephone pole at corner, azimuth 186° 47′, distance 45.3 feet; nail in blaze of wild cherry tree, azimuth 144° 47′, distance 140.6 feet	38	12	27.56	85	43	46.03
B. M. 104, on southwest corner of Hess lane and Poplar level pike, nail in corner of fence post, azimuth 312° 52′, distance 51.2 feet; nail in blaze on locust tree, azimuth 280° 27′, distance 103.5 feet	38	12	41.80	85	43	16.13
B. M. 105, Poplar level pike and Gray's lane, nail in blaze on small elm tree, azimuth 176° 34′, distance 43.7 feet; nail in blaze on large sycamore tree, azimuth 272° 25′, distance 54.7 feet	38	12	22.22	85	42	48.56
B.M. 106, on south side of Newburg pike at lane south at bridge, northeast corner of stone culvert, azimuth 152° 40′, distance 2.9 feet; nail in blaze on sycamore tree, azimuth 336° 15′, distance 17.5 feet	38	12	56.66	85	42	20.96
B. M. 107, south side of Newberg pike at Ropewalk lane north, nail in blaze on maple tree, azimuth 212° 30′, distance 75.9 feet; nail in blaze on locust tree, azimuth 144° 17′, distance 37.4 feet	38	13	21.31	85	42	38.66
B. M. 108, on north side of Taylorsville road at Ropewalk lane south, nail in blaze on large sycamore tree, azimuth 129° 41′, distance 71.4 feet; nail in blaze on maple tree, azimuth 56° 04′, distance 78.4 feet	38	13	41.52	85	42	03.90
B. M. 109, on southeast corner of Baxter and Edmunds avenues, center of hydrant, azimuth 96° 50′, distance 57.1 feet; center of manhole, azimuth 295° 40′, distance 10 feet	38	13	56.42	85	42	38.76
B. M. 110, on southeast corner of Baxter and Lucia avenues, corner of grocery store, azimuth 42° 55′, distance 20.8 feet; center of hydrant, azimuth 293° 40′, distance 8.9 feet	38	14	11.72	85	43	06.53
B. M. 111, on northwest corner of Baxter and Christy avenues, east corner of saloon, azimuth 141° 20′, distance 15.1 feet; J. E. Kirchdorfer's hardware store, azimuth 331° 27′, distance 55.2 feet	38	14	30.34	85	43	33.23
B. M. 112, on southwest corner of Baxter avenue and Underhill street, corner of saloon, azimuth 141° 19′, distance 9.2 feet; corner of brick building, azimuth 329° 20′	38	14	50.90	85	43	49.32
B. M. 113, north end of parking of Cherokee parkway at Willow avenue west, northeast corner of porch of Belvoir apartments, azimuth 113 55′, distance 77.7 feet; hydrant, azimuth 240° 33′, distance 88.9 feet	38	14	10.84	85	42	35.21
B. M. 114, on Cherokee Park and Longest avenue, northwest corner of drive along west side of, corner of Cherokee Park, nail in elm tree, azimuth 54° 37′, distance 64.9 feet; corner of stone wall, azimuth 132° 11′, distance 19.9 feet	38	14	24.04	85	42	23.68
B. M. 115, on Workhouse road and Long Cliff avenue north, on southeast corner, center of fire plug, azimuth 214° 19′, distance 47.2 feet; southeast corner of warehouse, azimuth 147° 33′, distance 62.6 feet	38	14	42.30	85	42	05.54
B. M. 116, on Long Cliff and Peterson avenues, on northwest corner, nail in elm tree, azimuth 144° 28′, distance 52.2 feet; nail in blaze on small sycamore tree, azimuth 274° 21′, distance 56.5 feet	38	14	53.86	85	41	49.50
B. M. 117, on Shelbyville road at Cannon's lane, south, on south side, nail in blaze on locust tree, azimuth 141° 55′, distance 162.6 feet; center of pump, azimuth 293° 03′, distance 69.6 feet	38	15	13.11	85	40	13.76
B. M. 118, at east corner of Workhouse and Shelbyville roads, at St. Matthews, southwest corner of brick foundation to house, azimuth 147° 24′, distance 49.2 feet; center of millstone No. 5, azimuth 34° 58′, distance 32.6 feet	38	15	09.50	85	39	25.38

Geographic positions at Louisville—Continued.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
B. M. 119, on Workhouse road and Cannon's lane, at southwest corner, nail in blaze on large tree, azimuth 68° 16′, distance 104.4 feet; southwest corner of stone culvert, azimuth 337° 30′, distance 11 feet.	38	14	57.04	85	40	01.13
B. M. 120, on Workhouse road, south side of, 1,935 feet west of Cannon's lane, nail in blaze on large tree, azimuth 81° 42′, distance 67.8 feet; nail in telephone pole, azimuth 126° 46′, distance 86.4 feet	38	14	53.33	85	40	24.93
B. M. 121, south side of Workhouse road, 400 feet west of Stiltz lane, telephone post, azimuth 54° 43′, distance 25.9 feet; nail in tree, azimuth 285° 12′, distance 39 feet	38	14	51.93	85	40	54.57
B. M 122, on J. M. Atherton's farm, at gate about 700 feet south of his house, center of stone lot monument, azimuth 162° 38′, distance 130.9 feet; nail in small hackberry tree, azimuth 111° 25′, distance 12.5 feet.	38	14	22.17	85	40	56.51
B. M. 123, on north end of road near Alexander's residence and about on Alexander and Cown's property line, nail in blaze on locust, azimuth 136° 41′, distance 67 feet; west corner of Alexander's porch, azimuth 265° 01′, distance 146.9 feet	38	13	50.11	85	40	40.25
B. M. 124, on Woodbourne avenue, 2,770 feet northeast of Baxter avenue, nail in blaze on hackberry tree, azimuth 110° 46′; nail in blaze on hackberry, azimuth 239° 06′	38	13	40.25	85	40	59.54
B. M. 125, on Taylorsville road at Woodbourne avenue northeast, south side, nail in blaze on cottonwood, azimuth 153° 18′, distance 72.4 feet; nail in blaze on cottonwood tree, azimuth 242° 10′, distance 03.7 feet.	38	13	25.33	85	41	28.66
B. M. 126, on Taylorsville road, north side, at east end of siding to electric railroad, telephone pole on Taylorsville road, azimuth 70° 46′; tree, azimuth 132° 36′, distance 44 feet	38	13	24.50	85	40	45.11
B. M. 127, on farm of Doctor Dermatt, north end of private lane, 0.5 mile southeast of Duck's Point, nail in blaze on maple tree, azimuth 40° 36′, distance 101.1 feet; nail in blaze on beech tree, azimuth 3° 15′, distance 73.7 feet	38	13	06.21	85	40	55.90
B. M. 128, on Adams place, south side of road, northwest at entrance to, north corner of stone gatepost, azimuth 41° 29′, distance 8.9 feet; nail in blaze on small cherry tree, azimuth 162° 48′, distance 38.2 feet	38	12	53.32	85	41	18.02
B. M. 129, on Newburg pike at lane north to Adams place, north side of, west corner of barn, azimuth 254° 10′, distance 121.1 feet; west corner of stone gatepost, azimuth 316° 24′, distance 64.9 feet	38	12	37.91	85	41	40.79
B. M. 130, on Newburg pike, south side at Mrs. Wilder's private road, northeast, nail in blaze on locust tree, azimuth 259° 48′, distance 59.6 feet; nail in blaze on elm tree, azimuth 331° 04′, distance 32.2 feet.	38	12	45.81	85	42	00.79
B. M. 131, on southwest corner of Gass avenue and Hoertz street, southeast corner of retaining wall, azimuth 263° 31′, distance 77.4 feet; store No. 1209, azimuth 349° 31′, distance 9.2 feet	38	13	38.62	85	44	11.11
B. M. 132, north side of Poplar level road, 700 feet southeast of Texas street, nail in locust tree, azimuth 334° 28′, distance 100.6 feet; small locust tree, azimuth 50° 53′, distance 41.2 feet	38	13	28.14	85	43	53.06
B. M. 133, west side of Poplar level pike just north of Clark's lane, west corner of stone culvert, azimuth 306° 42′, distance 59.8 feet; nail in blaze on white-oak tree, azimuth 66° 08′, distance 37 feet	38	13	11.38	85	43	45.45
B. M. 134, south side of Poplar level pike, tree, azimuth 335° 18′, distance 31.6 feet; tree, azimuth 112° 52′, distance 13.5 feet	38	12	54.70	85	43	31.60
South meridian stone, regulation stone post with tablet in top, in south part of Shawnee Park, 209 feet north of driveway marked "South Stone"	38	15	04.80	85	49	48.09
North meridian stone, 1,227.3 feet north of south stone, same size and marked "North Stone"	38	15	16.93	85	49	48.09

RUSSELL AND WAYNE COUNTIES.

MONTICELLO QUADRANGLE.

The following geographic positions were determined by primary traverse run in the spring of 1906 by J. R. Ellis, topographic aid. The line starts at Jacks Knob triangulation station and follows highways around the borders of the quadrangle, closing on Jacks Knob:

Geographic positions along highways.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Jacks Knob triangulation station, 1.5 miles southwest of Cartwright post-office, best ascended from the divide on Monticello road, about 1 mile west of post-office, on land of Nathan Ballenger, who lives northwest of Knob on main road. Station mark: A stone post with brass plug inserted, stamped "U. S. G. S"	36	44	17.46	85	05	25.96
Cartwright post-office, forks of road 400 feet west of	36	45	05.0	85	04	46.7
Cartwright post-office, 1 mile east of arrow on gate to field on south side of road	36	45	28.5	85	03	37.6
Schoolhouse No. 1, T road north, just east of	36	45	37.6	85	02	26.9
Alpha post-office, T road north, in southwest corner of H. T. Denny's field, northeast corner of drug store and post-office, bears S. 56° 20′ W. distant 58 feet; nail in small walnut tree bears N. 19° 00′ W., distant 8.7 feet; in limestone 30 by 8 by 10 inches, aluminum tablet stamped "Prim. Trav. Sta. No. 2, 1906"	36	46	01.4	85	00	34.6
Alpha post-office, 600 feet east of Denny's store and post-office, stone between Clinton and Wayne counties, on south side of road	36	45	58.1	85	00	29.0
Wait post-office, T road north, just east of, 30 feet northwest to corner yard fence	36	46	11.5	84	59	13.2
Zula post-office, 300 feet north of, 58 feet west to telephone pole, cross cut in blaze on northeast face of cedar tree south side of road	36	46	18.7	84	58	52.8
Old Glory schoolhouse, 0.25 mile north of, T road southeast, 27 feet west to cross on fence post, 21 feet southeast to corner rail fence	36	46	32.0	84	57	29.8
Turkey Ridge schoolhouse, No. 28, large cross cut on gum tree about 200 feet north of	36	46	06.9	84	55	49.4
Shearer Valley post-office, 0.2 mile north of, just south of church at T road west, north azimuth mark, 6 feet northwest of mark cross cut on tree; 10.4 feet northwest, nail in blaze on tree	36	46	07.7	84	55	20.8
Forks of road on top of ridge, 7 feet due east to cross on small cedar	36	45	56.6	84	54	17.6
Cooper, crossroads at Hurt's farm, 1 mile west of, 20 feet south to corner rail fence	36	46	30.0	84	52	56.9
Cooper, in northeast corner of foundation of public school, aluminum tablet stamped "Prim. Trav. Sta. No. 3, 1906"	36	46	16.8	84	51	44.6
Sumpter post-office, 0.5 mile north of, cross on gatepost to farm owned by George Coffee, in Sumpter's lane	36	45	31.2	84	50	49.7
Harriman oil lease, arrow painted on northeast corner of tool house at crossroads on top of Coffee Hill	36	45	35.5	84	49	03.4
Coffee Hill, forks of road on east side of, 22 feet northwest to stump, 11 feet east to cross on small tree	36	45	42.6	84	48	32.4
Oil Valley post-office, large white-oak tree near center of road and about 40 feet west of blacksmith shop	36	46	31.8	84	48	05.4
Barrier post-office, forks of road 0.2 mile northeast of, in limestone bowlder near northwest corner of triangle formed by forks of road, aluminum tablet stamped "Prim. Trav. Sta. No. 4, 1906"	36	46	07.8	84	45	57.2
Medekle (P.) residence, T road south, 22 feet west to small stump, 36 feet southeast to guidepost	36	45	30.4	84	44	29.3
Coopervlile post-office, arrow painted on southeast corner of store	36	45	46.5	84	43	52.2
Ash tree, top of hill, arrow painted on tree (blazed on four sides)	36	46	13.1	84	43	17.4
Pilot Rock, T road north, 1 mile west and 0.5 mile south of, 27 feet south to cross on rail fence, 52 feet west to arrow on rail fence	36	47	44.9	84	42	40.5
Dick & Lovell's store, forks of road, cross cut on northwest side of oak tree	36	48	44.6	84	42	17.7
Gregory post-office, forks of road 500 feet east of, 21 feet southeast to cross on rail fence, 25 feet west to arrow painted on stone	36	49	47.4	84	42	02.9
Boston store, T road northwest, 24 feet south to north corner of store, 55 feet west to southeast corner of board fence	36	49	33.7	84	43	58.4
Sawmill site, arrow painted on telephone pole southeast of	36	49	52.4	84	45	03.4
Smith's store, 700 feet east of, road east, 9 feet southwest to large stump	36	50	36.1	84	45	51.6
Spann post-office, 0.5 mile west of, north side of crossroads on top of ridge, nail in blaze on black gum tree bears N. 79° 45′ E., distant 5.7 feet; nail in blaze on hickory tree bears S. 11° 3′ W., distant 78.7 feet; in sandstone 30 by 7 by 15 inches, aluminum tablet stamped "Prim. Trav. Sta. No. 5, 1906"	36	51	08.2	84	46	18.0
Sawmill and spring, T road west, 29 feet southwest to cross and arrow on small sycamore, 42 feet southeast to southwest corner sawmill	36	52	13.6	84	46	38.6

Geographic positions along highways—Continued.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Steubenville post-office, 700 feet north of, T road east at Monticello and Burnside pike. 16 feet northwest to telephone pole, 27 feet northeast to post at corner fence	36	53	16.3	84	48	06.6
Steubenville post-office, 1 mile northeast of, southwest corner of porch to tollgate house	36	53	39.3	84	47	24.0
Shepherd's store, road southeast about 600 feet northeast of, 25 feet north to cross on telephone pole, 45 feet northwest to large black-oak tree	36	54	12.2	84	46	55.8
Metcalf (G. C.) residence, T road west, 18 feet northeast to large walnut tree, 21 feet southeast to corner yard fence	36	55	03.7	84	46	42.4
Millsprings, T road west, 12 feet due east to northwest corner of Lanier's store	36	55	59.9	84	46	43.5
Beechwood schoolhouse, private road south, 7 feet west to cross on small black-oak tree	36	57	42.2	84	46	49.7
Millsprings and national-cemetery road, about 100 feet south of crossroads at corner of Shepherd, Rousseau & Marcum's farm, nail in walnut tree at crossroads bears N. 1° 45′ E., distant 111.2 feet; nail in walnut tree bears N. 37° 30′ W., distant 104.6 feet; cemented in top of blue limestone 26 by 9 by 9 inches, aluminum tablet stamped "Prim. Trav. Sta. No. 6, 1906"	36	58	15.2	84	46	51.4
Whiteoak Creek, gate about 150 feet west of, 0.4 mile south of, grist mill	36	58	11.6	84	47	31.4
Trimble and Merrick's store, T road northwest about 400 feet southwest of, 15 feet east to arrow on stump, 30 feet northwest to cross on small walnut	36	58	14.3	84	48	56.3
Richardson's residence, cross on small cedar tree at road	36	57	58.5	84	49	56.8
Forbush Creek, arrow painted on large dead elm about 200 feet west of ford on	36	58	08.7	84	50	30.4
Dell post-office (formerly Ferris), 300 feet south of, in large bowlder in southwest corner of field of M. H. Hatfield, aluminum tablet stamped "Prim. Trav. Sta. No. 7, 1906"	36	57	55.3	84	52	26.0
Dell and Jabez, T road east halfway between, 18 feet southwest to cross on white-oak sapling, 15 feet northeast to cross on white-oak sapling	36	58	38.7	84	53	09.5
Jabez post-office, crossroads	36	59	14.2	84	53	25.9
Military Springs, Baptist Church, T road south 0.25 mile southwest of, 21 feet west to cross on white-oak tree, 19 feet northwest to cross on board fence	36	58	53.8	84	54	34.7
Jamestown road and Wolf Creek crossing, forks of road just east, 33 feet north to cross on cottonwood tree, 53 feet west to cross on telephone pole	36	58	59.0	84	57	01.2
Ono, crossroads, cross and arrow painted on corner of yard fence	36	59	21.2	84	57	59.4
McFarland Creek, 350 feet above junction with Caney Fork, in east face of ledge of stone on west side of, aluminum tablet stamped "Prim. Trav. Sta. No. 8, 1906"	36	59	18.9	84	59	33.3
Hickory tree at point where road leaves creek bottom, arrow painted on	36	58	15.6	85	00	14.0
Caney Fork and Wolf Creek, junction of T road west just north of, 24 feet north to post with auger hole, 24 feet southwest to cross on corner fence post	36	57	12.7	85	00	05.0
McFall's store, at mouth of Wolf Creek, north side of Cumberland River, cross and "U. S. G. S." cut on northwest corner of large stone	36	56	29.1	85	00	33.1
Stokes post-office, south gatepost to gate across road about 450 feet east of	36	55	44.1	85	01	32.3
Clyde post-office, just west of, center of road where Russell-Wayne county line crosses	36	53	56.3	84	59	38.5
Stringer's store, road east	36	53	24.8	84	59	54.0
Stephen Sullivan's residence, road west, cross painted on chestnut tree	36	53	04.6	84	59	52.9
Poor (Eph.) farm, road northeast to	36	52	48.4	84	58	39.7
Road southwest, 12 feet east to stump	36	52	55.9	84	58	08.0
Old store building, center of road opposite	36	52	37.1	84	57	27.3
Parnell post-office, 0.5 mile west of, northwest corner of foundation to schoolhouse, aluminum tablet stamped "Prim. Trav. Sta. No. 9, 1906"	36	51	54.8	84	57	07.4
Beaver Creek, forks of road, 500 feet north of Cooper residence, 27 feet southeast to blaze on large cottonwood tree, 21 feet west to large stump	36	50	25.6	84	58	18.8
Wild Goose road at road north, 1 mile south of Cooper farm, 30 feet west to cross on dogwood tree, 27 feet southeast to arrow on rail fence	36	49	14.1	84	58	15.3
Susie post-office, road southwest, 9 feet south to ring nailed to tree, 42 feet northeast to center of yard gate	36	47	49.2	84	57	55.8
Otter Creek, at Dug Ford, middle of	36	47	23.3	84	58	33.1
Wait post-office, 1 mile north of, crossroads 50 feet south of gate, 45 feet northeast to stone corner at gate, 34 feet south to large white-oak tree	36	46	55.2	84	59	02.2

FRANKLIN AND OWEN COUNTIES.

SADIEVILLE QUADRANGLE.

The line starts from the railroad crossing at Switzer and follows highways north near the west border of the Sadieville quadrangle and the east border of the Lockport quadrangle to the intersection of the Monterey, Overton, and Georgetown pikes, at Hesler. The field work was done by J. R. Ellis, assistant topographer, in May, 1906.

Geographic positions along highways.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
T road up branch, 20 feet southwest to J. Stafford's mail box, 27 feet northwest to corner of rail fence	38	16	07.3	84	44	49.0
Franklin-Scott county line, large sugar-maple tree on	38	16	43.9	84	44	04.0
Yates schoolhouse, pike southwest at, 24 feet southeast to corner fence post, 24 feet southwest to mail box	38	17	22.7	84	42	47.8
Hall's store, T road southwest, on Franklin-Scott County line, 33 feet northwest to corner of store, 54 feet north to W. Baldwin's mail box.	38	18	32.7	84	44	15.5
Elmville, center of pike just west of road, up creek, 27 feet west to Wash's shop, 24 feet north to corner of fence	38	20	28.3	84	45	40.8
Corner Franklin, Scott, and Owen counties, corner stone	38	21	08.4	84	44	25.3
Major Anderson's house, east corner of bridge over branch southwest just north of	38	21	37.6	84	43	16.1
Sleterville, post on Scott-Owen county line near	38	22	12.0	84	42	21.7
Mr. Bender's house, pike west at, 20 feet southeast to corner of porch, 30 feet west to cross on hickory tree	38	22	41.2	84	42	31.0
North corner of W. T. Watson's barn, aluminum tablet stamped "Prim. Trav. Sta. No. 1, 1906"	38	23	22.0	84	43	00.8
Beechwood, T pike east, 21 feet northeast to corner of store and post-office, 42 feet southeast to corner of garden fence	38	23	38.9	84	43	15.3
J. A. Watson's house, T pike southwest to Bethany, 21 feet northeast to southwest corner of barn, 69 feet northwest to center of small bridge	38	24	50.7	84	43	42.8
Old toll gate, pike northeast, 10 feet northwest to corner of yard fence.	38	25	21.0	84	43	45.1
Fairbanks store and post-office, pike west, 27 feet west to southeast corner of store, 25 feet southeast to cross on fence post	38	25	58.5	84	43	57.3
East Eagle post-office, dirt road southwest about 450 feet south of, 24 feet northwest to cross on tree, 30 feet northeast to stump	38	26	54.2	84	45	30.9
Hesler, intersection of pikes	38	27	48.0	84	46	36.7

ANDERSON, JEFFERSON, SHELBY, AND SPENCER COUNTIES.

SHELBYVILLE AND TAYLORSVILLE QUADRANGLES.

The following geographic positions on the United States standard datum were determined by primary traverse in 1905 by C. B. Kendall, field assistant. The north line begins with an adjusted position at Hatton and follows the Chesapeake and Ohio Railway, public roads, and the Louisville and Nashville Railroad west along the north border of the quadrangles to Anchorage. The south line starts from an adjusted position at Smithville and follows highways via Taylorsville to an adjusted position at Gudgel.

SHELBYVILLE QUADRANGLE (SHELBY, SPENCER, AND ANDERSON COUNTIES).

Geographic positions along Louisville and Nashville Railroad between Hatton and Bagdad.

Station.	Latitude.			Longitude.		
	°	'	"	°	'	"
Hatton, in front yard of G. W. Stockton's tenement house, opposite Roberts & Wright's general store on north side of Louisville and Nashville R. R., southeast corner brick chimney to house bears N. 3° 10' E., distant 78.5 feet; nail in sycamore tree on railway property bears S. 33° E., distant 29.8 feet; lower hinge to front-yard gate bears S. 86° 30' W., distant 23.5 feet, iron post stamped "Prim. Trav. Sta. No. 24"	38	13	35.4	85	00	23.6
Hatton, 1.1 miles west of, second-class road crossing, center of track	38	13	45.8	85	01	48.0
Hatton, 1.7 miles west of, second-class road crossing, center of track	38	13	47.5	85	02	13.2
Consolation station, 0.9 mile southeast of, second-class road crossing, center of track	38	14	41.3	85	02	16.5
Consolation station, overhead-pike crossing, center of track	38	15	25.5	85	02	31.6
Bagdad station, 250 feet south of, pike crossing, center of track	38	15	43.2	85	03	23.9

Geographic positions along public highways between Bagdad and Shelbyville.

Station.	Latitude.			Longitude.		
	°	'	"	°	'	"
Bagdad station, 1.6 miles northwest of, T road south, 15 feet southwest to corner post of wire fence, 25 feet southeast to corner post of wire fence	38	15	53.6	85	05	06.0
Christiansburg station, 1 mile south of, at junction of Shelbyville-Christiansburg pike and pike leading east, at old toll gate, in northwest corner of junction; iron post stamped "Prim. Trav. Sta. No. 3, 1905"	38	16	00.3	85	06	19.4
Shelbyville-Christiansburg pike crossing Chesapeake and Ohio Rwy., center of track	38	15	58.1	85	07	22.8
Blacksmith shop, three corners, T road north, 40 feet north to car shop, 10 feet south to wire fence	38	15	56.0	85	08	40.9
Four corners, second-class crossroads, 60 feet southeast to Chesapeake and Ohio Rwy. 25 feet northwest to red gate	38	15	08.4	85	09	36.6
Chesapeake and Ohio Rwy. milepost "Lou 34", 900 feet northeast of T road to southeast, 60 feet southeast, to railroad crossing, 25 feet south to walnut tree	38	14	15.4	85	10	31.9
Shelbyville, 2.1 miles east of, T road south, 25 feet southwest to corner post of wire fence, 30 feet southeast to corner post of wire fence	38	13	50.0	85	11	21.3
Shelbyville, Shelby County court-house, 10 feet east of southeast corner, iron post stamped "Prim. Trav. Sta. No. 2, 1905"	38	12	39.2	85	12	57.1
Shelbyville, intersection of Washington and Seventh streets	38	12	42.0	85	13	07.5

Geographic positions along Louisville and Nashville Railroad between Shelbyville and Anchorage.

Station.	Latitude.			Longitude.		
	°	'	"	°	'	"
Shelbyville, 1.3 miles west of; Smithfield pike crossing of Louisville and Nashville R. R. at milk station, center of track	38	13	11.4	85	14	06.3

Geographic positions along highways on south border of quadrangle.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Little Mount, four corners, 30 feet south to telephone pole, 36 feet northwest to stonewall, 90 feet east to corner of blacksmith shop	38	03	40.1	85	15	05.3
Big Beech Creek, east end of covered bridge over, roads northeast, east, and south	38	03	15.0	85	13	27.3
Old Marrattoy post-office, three corners, T road to east	38	02	33.7	85	13	00.6
Old Marrattoy post-office, in forks of road, in northwest corner of front yard to residence of W. M. Welch; iron post stamped "Prim. Trav. Sta. No. 5, 1905"	38	02	33.4	85	13	00.4
Briar Ridge Reformed Church, three corners at, three trees in triangle.	38	01	14.7	85	12	27.3
Briar Ridge Reformed Church, 1.4 miles southeast of, T road to northeast, junction of Van Buren and Mount Eden roads, 12 feet east to gate, 18 feet northwest to corner of rail fence	38	00	55.0	85	11	01.5
Little Beech Creek, center of, at second-class fork up valley	38	01	36.5	85	10	40.6
Mount Eden, about 1.25 miles southwest of, four corners, center of road opposite barn, 20 feet west to barn door, 25 feet east to step at rock wall	38	02	06.1	85	09	34.4
Mount Eden, about 2 miles south of, forks of roads south, southeast, and east, 60 feet northwest to old stump, 30 feet west to sycamore, 90 feet southeast to dead tree	38	01	48.7	85	08	31.4
Wycoff's old mill place, 1 mile northwest of, forks second-class road to southwest 25 feet southwest so gate, 10 feet north to barn	38	01	01.0	85	08	15.5
Wycoff's old mill place, forks at roads northwest up hill and northeast of Crooked Creek, center of triangle at forks	38	00	31.2	85	07	27.1
Wycoff's old mill place, 1.2 miles southeast of, forks of roads northwest and southeast, 50 feet north to oak in yard, 15 feet southwest to rail fence	37	59	48.5	85	07	29.2
Vandyke post-office, 0.5 mile east of, junction of Pleasant Grove Ridge road and Vanburen-Lawrenceburg pike, 375 feet west of, in northeast corner of front yard to residence of J. T. Edwards, iron post stamped "Prim. Trav. Sta. No. 6, 1905"	37	59	05.7	85	06	40.4
Vandyke post-office, 0.5 mile east of, junction of Pleasant Grove Ridge road and Vanburen-Lawrenceburg pike, south edge of pike at junction	37	59	08.5	85	06	37.2
Vandyke post-office, about 2.5 miles east of, junction of Vanburen-Lawrenceburg and Mount Eden Lawrenceburg pikes, 20 feet northwest to stone wall, 50 feet southwest to large elm	38	00	22.4	85	05	12.6
Timber Creek, center of covered bridge over	38	00	15.0	85	04	31.3
Glensboro, three corners at blacksmith shop, pike to south, 40 feet south to corner of yellow store, 40 feet southwest to corner of yellow dwelling	38	00	16.1	85	03	35.5
Glensboro, 1.4 miles east of, forks of second-class road to northeast, 30 feet northwest to corner of stonewall, 50 feet east to apple tree	38	00	29.6	85	02	10.4
Petty post-office, 0.25 mile north of, T road south, 50 feet southeast to telephone pole, 35 feet southwest to corner post of wire fence, 350 feet south to covered bridge	38	00	30.8	85	01	31.0
Petty, 1 mile west of, forks of second-class road to southeast, 15 feet north to telephone pole painted "682," 60 feet east to oak tree	38	00	33.4	85	00	30.5
Gudgel, blue-limestone post 28 by 6 by 6 inches, with hole drilled and "U. S. G. S." cut in top, in front yard of Lizzie Burgess's house, 1.2 feet from front fence, 19 feet west of gate, corner of buggy shed bears N. 77° 30′ W., distant 26.6 feet	38	00	34.7	84	59	27.6

TAYLORSVILLE QUADRANGLE (JEFFERSON, SHELBY, AND SPENCER COUNTIES).

Geographic positions along Louisville and Nashville Railroad between Shelbyville and Anchorage.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Milk station, second-class road crossing, center of track	38	13	52.8	85	16	[illegible]
Scotts station, pike crossing, center of track	38	14	01.3	85	17	08.9
Scotts station, 1.3 miles west of, second-class road crossing, center of track	38	13	29.6	85	18	24.5
Simpsonville station, 0.7 mile east of, second-class road crossing, center of track	38	13	33.6	85	20	35.9
Simpsonville, in southeast corner of grounds of Simpsonville Masonic lodge, iron post stamped "Prim. Trav. Sta. No. 1, 1905"	38	13	20.8	85	21	33.4
Simpsonville, at west edge of, State pike crossing of Louisville and Nashville R. R., center of track	38	13	21.4	85	21	44.7
Connors station, road crossing, center of track	38	13	23.8	85	23	25.7
Longrun station, road crossing, center of main track	38	13	48.0	85	25	30.0
Floyds Fork, 0.25 mile east of, road crossing, center of main track	38	14	25.8	85	27	37.0
Beckleys station, road crossing, center of track	38	15	02.6	85	28	32.3
Avoca station, road crossing, north rail, main track	38	15	22.1	85	30	01.[illegible]
Anchorage, 1 mile east of, road crossing at milepost "Lou 13," center of track	38	15	38.3	85	31	24.7

Geographic positions along highways on south border of quadrangle.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Smithville, 0.9 mile southeast of, junction of Salt River road and pike, 10 feet northeast to rock wall, 90 feet south to crooked oak tree	38	00	41.3	85	29	53.3
Smithville, 1.7 miles east of, three corners, second-class T road to south, 10 feet south to gate	38	00	29.8	85	29	10.3
Lucas ford of Salt River, 0.75 mile west of, T road to south, 35 feet south to red gate	38	00	40.6	85	28	14.7
Lucas ford of Salt River, 600 feet north of, forks of road south and west, 10 feet north to corner of crib, 40 feet southwest to fence	38	01	19.2	85	28	11.1
Waterford, 1.7 miles southwest of, loop in main road, second-class road to south at white barn, 70 feet north to large oak, 40 feet west to lot gate	38	01	07.6	85	27	06.6
Waterford, 0.8 mile southwest of, three corners at bend of road northeast, second-class T road to southwest, 15 feet southwest to gate, 20 feet south to corner of house	38	01	50.1	85	26	56.4
Waterford, at north edge of, junction of Taylorsville, Waterford, and Elk Creek pikes, at blacksmith shop, 70 feet north to center of small bridge, 130 feet east to center of Plumb Creek	38	02	20.3	85	26	13.9
Waterford, 1 mile east of, forks, pike to west, public road to south, 15 feet north to mail box, 40 feet southwest to corner of wire fence	38	02	03.9	85	25	22.5
Waterford, 2 miles west of, four corners near top of hill, second-class crossroads, 5 feet north to wire gate, 40 feet south to white gate	38	01	47.6	85	24	16.8
Taylorsville, 2.4 miles west of, forks, roads east and south, 30 feet west to corner of wire and rail fence, 35 feet northeast to farm gate, 90 feet southeast to two walnut trees	38	01	49.3	85	23	18.9
Taylorsville, 1.4 miles west of, forks, second-class road to northwest, 15 feet north to wire fence, 35 feet south to board and wire fence, 60 feet southeast to telephone pole	38	01	42.2	85	22	29.5
Taylorsville, at west edge of, forks of pike north and west, 15 feet south to stonewall, 40 feet north to telephone pole	38	01	48.0	85	21	09.4
Taylorsville, Spencer County court-house, southwest corner of, iron post stamped "Prim. Trav. Sta. No. 4, 1905"	38	01	51.0	85	20	41.8
Taylorsville, 1.6 miles east of, forks, second-class road to south	38	02	00.5	85	19	00.8
Taylorsville, 2.1 mile east of, T road south, 35 feet southeast to corner post of wire fence, 35 feet west to corner post of wire fence	38	01	57.0	85	18	23.2
Three corners, second-class T road to north, 15 feet north to gate	38	02	22.7	85	17	31.3
Little Mount, 1.7 miles west of, three corners, second-class road to northwest, 25 feet northwest to gate, 40 feet east to locust tree	38	02	55.3	85	16	24.6

LOUISIANA.

PRIMARY TRAVERSE.

ASCENSION, EAST BATON ROUGE, AND IBERVILLE PARISHES.

BATON ROUGE QUADRANGLE.

The following geographic positions were determined by primary traverse in November, 1905, by C. B. Kendall, field assistant.

The line starts at Baton Rouge and runs northeasterly via highways to Comite post-office, thence southerly via Foreman, Hopevilla, and Dutchtown to Geismar, on the Yazoo and Mississippi Valley Railroad, thence northwesterly along said railroad to St. Gabriel.

Positions are based on the Baton Rouge astronomic datum as given in the report of the Chief of Engineers, United States Army, for 1887, Part IV, page 2783.

Geographic positions along highways.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Baton Rouge, brick tower on penitentiary	30	27	04.2	91	10	55.6
Cowboys' Exchange, road north	30	27	14.9	91	10	00.8
Three corners, road north	30	28	11.6	91	07	38.9
Three corners, road north	30	29	04.6	91	05	21.8
Comite, store and post-office, 160 feet northeast of, marble post 30 by 6 by 3 inches set 28 inches in ground, "G. S." cut in top of post	30	30	29.3	91	01	55.6
Comite, store and post-office, 300 feet southwest of, marble post 30 by 6 by 3 inches set 28 inches in ground, "G. S." cut in top of post; the two posts are 453 feet apart, azimuth between them is 34° 25′ 35″	30	30	25.6	91	01	58.6
Rosehill Baptist Church, T road south	30	29	41.2	91	03	37.2
Rosehill Baptist Church, 1.5 miles south of, four corners, township line, 20 feet northeast to corner of wire fence, 45 feet west to oak tree.	30	28	28.0	91	03	28.2
Harelson's store, 1.25 miles northwest of, road forks, second-class road northwest, 40 feet northeast to bush, 50 feet southeast to bush	30	27	12.0	91	04	15.3
Harelson's store, three corners, T road north, 60 feet northeast to corner of store porch, 60 feet east to T road south	30	26	08.0	91	03	56.8
Jones Creek Church, 250 feet southeast of, three corners	30	25	56.1	91	02	25.6
Jones Creek Church, 1.75 miles southeast of, three corners near J. B. Cooper's mail box, 80 feet northwest to large oak, 90 feet south to corner wire fence	30	25	40.1	91	00	50.7
Phillips's (F. M.) mail box, three corners near, 20 feet northeast to cedar, 20 feet northwest to mail box	30	24	34.2	91	00	56.6
Clay Gut road, three corners at junction with T road north, 35 feet northwest to corner of wire fence, 60 feet southeast to large live oak.	30	23	32.8	91	01	05.7
Foreman post-office, 1.5 miles north of, three corners, T road south, 40 feet southwest to rail fence, 35 feet south to sweet gum	30	23	26.4	91	00	25.6
Foreman post-office, 1,000 feet east of, three corners, T road north	30	22	12.0	91	00	34.0
Foreman post-office, 1,000 feet southeast of, at northeast corner of St. Luke's Baptist Church, iron post stamped "Prim. Trav. Sta. No. 1, 1905"	30	22	09.4	91	00	35.1
Hopevilla, 1 mile northwest of, three corners, T road northeast, 15 feet northeast to small bridge, 90 feet west to oak tree	30	21	23.4	90	59	33.3
Hopevilla, center of Bayou Manchat at Hampton Ferry	30	20	42.0	90	58	58.0
Hopevilla, 0.75 mile south of, three corners, T road west, 25 feet southwest to corner of yard fence, 25 feet northwest to corner of rail fence.	30	20	07.2	90	58	54.2
Three corners, 200 feet southeast of store, T road east, 25 feet northeast to corner of fence, 30 feet southwest to front-yard gate	30	19	17.5	90	58	32.9
Forks of road, north and northeast, 30 feet southwest to thorn tree, 110 feet northeast to locust tree	30	18	48.9	90	58	21.4
Township line, three corners on, T road east	30	17	58.2	90	58	28.9
Forks of road at store, north and northeast, 70 feet east to store, 20 feet west to wire fence	30	17	29.0	90	58	42.0
Goodhope, four corners at, second-class road crossing	30	16	20.0	90	59	02.6
T. 9 S., R. 2 E., corner of secs. 14, 15, 22, and 23, 5 feet south of, four corners at Dutchtown	30	15	20.2	90	59	19.9
Dutchtown, southeast corner of intersection of public roads, in north face of corner of brick foundation of Picard, Geismar & Co.'s warehouse, aluminum tablet stamped "Prim. Trav. Sta. No. 2, 1905"	30	15	19.8	90	59	19.5
Dutchtown, 1.25 miles south of, center of Moore's bridge over New River	30	14	23.8	90	59	19.2
Three corners, T road west, 40 feet west to large oak, 60 feet northwest to gate	30	13	23.9	91	00	13.0
Three corners, T road southeast	30	12	32.8	91	01	05.8

Geographic positions along Yazoo and Mississippi Valley Railroad, Geismar to St. Gabriel.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Geismar station, road crossing 150 feet southeast of	30	12	18.4	91	01	21.0
Geismar, 125 feet southeast of station, 50 feet south of center of Yazoo and Mississippi Valley R. R., main track, in angle between railway and public road, Mississippi River Commission bench mark post "1891 P. B. M.," stamped "Prim. Trav. Sta. No. 3, 1905." A United States Geological Survey iron post was also set 1 foot west of Mississippi River Commission bench mark and stamped "Prim. Trav. Sta. No. 3, 1905"	30	12	18.3	91	01	21.9
Southwood station, 50 feet northwest of, center of main track, at road crossing	30	13	09.9	91	02	56.9
Ascension-Iberville parish line, center of track	30	13	22.6	91	03	30.7
Ascension-Iberville parish line, 0.6 mile northwest of, road crossing, 100 feet northwest of cotton gin	30	13	40.4	91	03	53.8
Bruns, 50 feet southeast of, road crossing	30	13	44.9	91	04	02.3
Bruns, 1.25 miles northwest of, second-class road crossing, point 10 feet west of	30	14	23.3	91	05	13.5
St. Gabriel station, 150 feet west of center of main track, on south edge of sidewalk leading west from station, Mississippi River Commission bench mark marked "U. S. P. B. M. 1891." A United States Geological Survey iron post was set near and stamped "Prim. Trav. Sta. No .4, 1905"	30	15	30.7	91	05	56.0
St. Gabriel, 0.75 mile southwest of, chimney on old Bagatelle sugar house	30	14	32.3	91	06	22.3

ASCENSION, ASSUMPTION, IBERVILLE, AND WEST BATON ROUGE PARISHES.

GROSSETETE AND WHITECASTLE QUADRANGLES.

The following geographic positions were determined by primary traverse run by C. B. Kendall, field assistant, in December, 1905. For the control of the Whitecastle quadrangle the line begins with the position of the east tower of the old Catholic Church at Donaldsonville and follows the Texas and Pacific Railway to Plattenville, thence along public roads west and northwest to the Whitecastle Lumber Company's railroad at Lake Natchez, thence along this railroad and public roads northeast to Whitecastle, thence along Texas and Pacific Railway to Plaquemine, where it is tied to the position of the Catholic Church spire

For the control of the Grossetete quadrangle the line begins with the position of the Catholic Church spire at Plaquemine and follows Bayou Plaquemine to its junction with Bayou Grossetete, thence along Bayou Grossetete northwest to Grossetete, thence along the Texas and Pacific Railway to Old Rosedale station, where it turns east along the old Louisiana Central Railroad grade to Baton Rouge and is tied to the position of the northwest tower of the Louisiana statehouse, also to primary traverse position as determined by E. L. McNair, topographer, in 1903.

A checked spur line was run from Old Rosedale station northwest along the Texas and Pacific Railway to Maringouin station.

Positions are based on the Baton Rouge datum, as given in the report of the Chief of Engineers, United States Army, for 1887, pages 2779–2784.

GROSSETETE QUADRANGLE (BATON ROUGE AND IBERVILLE PARISHES).

Geographic positions along highways.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Plaquemine, west edge of, junction of Court street and Bayou road, 25 feet southwest to center of small bridge, 20 feet northwest to corner of store porch	30	17	05.2	91	14	40.0
Plaquemine, 2.2 miles southwest of, 600 feet east of oil-pumping station, three corners, second-class T road to south, 40 feet south to railroad	30	16	23.1	91	15	30.9
Le Blanc's store, 1.1 miles northeast of, three corners, T road to south, 10 feet south to gate, 40 feet southwest to oak tree, 50 feet north to center of railroad	30	15	52.4	91	15	55.8
Le Blanc's store, three corners, T road to south, 30 feet south to gate, 30 feet southwest to corner store porch	30	15	00.8	91	16	17.3
Cockleburr lumber mill, center of water tank	30	14	51.6	91	16	54.8
Crescent post-office, 0.7 mile southwest of, three corners, T road to south, 20 feet southwest to corner of yard fence, 40 feet southeast to corner of yard fence	30	14	54.1	91	17	17.9
Ferguson's private ferry, three corners, road north to south landing of, 35 feet south to store door, 30 feet northeast to telephone pole	30	15	15.1	91	18	03.7
Seymour Ferry across Bayou Plaquemine, east landing of	30	15	30.2	91	19	10.3
Seymour Ferry, 150 feet north of east landing, at bend of road to south, at southwest corner of front-yard fence to residence of Frank Seymour, iron post stamped "Prim. Trav. Sta. No. 10, 1905"	30	15	31.6	91	19	09.7
Seymour Ferry, 0.6 mile northwest of, three corners, T road east to Joe Carter's ferry, 40 feet northeast to sweet gum, 50 feet south to sycamore stump	30	15	55.7	91	19	21.6
Seymour Ferry, 1.7 miles northwest of, center of bridge over small bayou	30	16	50.7	91	19	09.3
Seymour Ferry, 2.6 miles northwest of, point of land at junction of bayous Choctaw and Grossetete	30	17	30.1	91	18	56.4
Bayou William, 0.4 mile southeast of, three corners, second-class T road to west, at northeast corner of clearing, stake at west edge of road, marked "9-10"	30	18	01.5	91	19	29.6
Bayou William, center of bridge over	30	18	23.2	91	19	39.3
Bayou William, 0.9 mile northwest of, three corners, second-class T road to west, 100 feet south of southeast corner of clearing, 100 feet north of northeast corner of clearing	30	19	05.2	91	19	53.4
Bayou Catfish, 1.3 miles southeast of, scond-class road to south, 10 feet west to locust, 90 feet north to edge of Bayou Grossetete	30	19	49.6	91	20	45.4
Bayou Catfish, center of bridge over	30	20	23.9	91	21	49.5
Bayou Catfish, 1.6 miles northwest of, three corners, second-class T road west, 150 feet south of southeast corner of clearing, 25 feet southwest to gum tree, 50 feet east to edge of Bayou Grossetete	30	21	33.6	91	22	29.3
Bayou Catfish, 2.5 miles northwest of, three corners, second-class T road to southwest, 10 feet northwest to corner of wire fence, 10 feet southwest to corner of wire fence, 100 feet northeast to Bayou Grossetete	30	22	09.8	91	22	46.9
Grossetete, about 4.3 miles southeast of, at bend of bayou to northwest, forks of roads northwest and southwest, 60 feet southeast to maple tree, 50 feet north to edge of Bayou Grossetete	30	22	08.0	91	23	52.5
Grossetete, 3 miles southeast of, three corners, second-class T road to southwest, 30 feet southwest to chinaberry tree, 30 feet south to corner of wire fence, 15 feet northeast to top of levee	30	22	48.8	91	24	42.8
Grossetete, 1.6 miles southeast of, three corners, second-class T road leading over old drawbridge, 50 feet northwest to large live oak, 20 feet west to end of fence	30	23	48.7	91	25	02.2
Grossetete, 0.6 mile east of station, road crossing Texas and Pacific Rwy., 125 feet northwest of bridge over Bayou Grossetete, center of track	30	24	28.9	91	25	26.6

Geographic positions along Texas and Pacific Railway near Grossetete.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Grossetete station, 100 feet northeast of, at edge of railroad right of way at corner of street, 50 feet north of center main track Texas and Pacific Rwy., iron post stamped "Prim. Trav. Sta. No. 11, 1905"	30	24	38.9	91	26	03.0
Grossetete station, 0.9 mile northwest of, railroad crossing, Texas and Pacific Rwy. and lumber road leading west, center of track	30	25	08.1	91	26	48.3
Old Rosedale station at crossing Texas and Pacific Rwy. and Old Louisiana Central R. R. grade, public road crossing, center of track	30	26	04.9	91	27	51.1

Geographic positions along old Louisiana Central Railroad grade.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Rosedale post-office, four corners, 60 feet northwest to corner store, 30 feet southeast to corner of old platform, 180 feet east to center of bridge over Bayou Grossetete	30	26	34.5	91	27	08.1
Rosedale post-office, 1.2 miles east of, small bayou, center of bridge over	30	27	12.0	91	26	06.1
Rosedale post-office, 2.5 miles east of, center of bridge	30	27	46.8	91	25	01.5
Lake Crocodile, center of iron bridge over	30	28	41.2	91	23	15.1
Lake Crocodile, 1.6 miles east of, small bayou, center of bridge over	30	28	17.0	91	21	48.3
Lake Crocodile, 2.6 miles east of, second-class wood road to north, center of old grade	30	28	10.5	91	20	50.5
Four corners at old sawmill place, 2.6 miles west of, three corners, second-class T lane to south, 10 feet south to small bridge	30	28	11.5	91	19	21.8
Four corners at old sawmill place, 2.1 miles west of, three corners, second-class T road to south, 40 feet south to dead oak, 10 feet west to small bridge	30	28	11.0	91	18	49.6
Four corners at old sawmill place, 1 mile west of, four corners, second-class T road to south, cane-field road to north, 20 feet south to corner of wire fence, 40 feet southwest to gum tree	30	28	09.1	91	17	45.3
Old sawmill place, on Selvy plantation, about 5 miles west of Port Allen, four corners, crossroads, 15 feet north to small bridge, 35 feet south to wire fence	30	28	10.0	91	16	44.0
Port Allen, about 5 miles west of, four corners at west end of old plank road on Savoy plantation, in southwest corner of intersection, iron post stamped "Prim. Trav. Sta. No. 13, 1905"	30	28	09.6	91	16	44.5
Port Allen, 3.8 miles west of, forks, roads southwest and southeast at schoolhouse, center of old grade, 100 feet southwest to front door of schoolhouse	30	27	44.1	91	15	46.1
Port Allen, about 3 miles west of, second-class road crossing, center of old grade	30	27	35.6	91	14	56.8
Port Allen, 1.5 miles west of, second-class road crossing, 50 feet east of old trestle across three streams, center of old grade at road crossing	30	27	39.5	91	13	27.3
Port Allen, at west edge of, crossing of Texas and Pacific Rwy. and old grade of Louisiana Central R. R., center of track	30	27	42.0	91	12	35.8
Port Allen, West Baton Rouge court-house, in angle formed by east wall and north wall of porte-cochère, iron post stamped "Prim. Trav. Sta. No. 14, 1905"	30	27	40.7	91	12	21.2
Baton Rouge, intersection of Main and Lafayette streets, center of car track	30	27	08.6	91	11	20.9
Baton Rouge, northwest tower of Louisiana statehouse, United States Engineers' triangulation station	30	26	51.56	91	11	20.29
Baton Rouge post-office, 150 feet east of, in park at foot of Church street, Mississippi River Commission P. B. M	30	26	52.87	91	11	15.28
Baton Rouge, intersection of North boulevard and Dufrocq street, center of street-car track	30	26	55.6	91	10	07.9
Baton Rouge, Cowboys' Exchange, three corners, T road to northwest	30	27	14.9	91	10	00.7

Geographic positions along Texas and Pacific Railway, Rosedale to Maringouin.

[Checked spur line.]

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
New Rosedale station, 1,000 feet northwest of, road crossing, center of track	30	26	30.9	91	28	19.6
New Rosedale, 1.7 miles northwest of, at cotton gin, crossing of West Oak lane, center of track	30	27	30.1	91	29	21.9
Slack's cotton gin, 400 feet northwest of, road crossing, center of track	30	27	56.0	91	29	45.5
Maringouin, 1 mile southeast of, road crossing, center of track	30	28	44.2	91	30	29.3
Maringouin station, 50 feet southeast of, street crossing, center of main track	30	29	30.5	91	31	11.4
Maringouin station, 200 feet north of, at south corner of Joseph Wolf's department store, iron post stamped "Prim. Trav. Sta. No. 12, 1905"	30	29	32.0	91	31	09.9

WHITECASTLE QUADRANGLE (ASCENSION, ASSUMPTION, AND IBERVILLE PARISHES).

Geographic positions along Texas and Pacific Railway between Donaldsonville and Plattenville.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Donaldsonville, east tower of old Catholic Church	30	06	18.05	90	58	58.25
Donaldsonville, cross on Catholic convent	30	06	14.36	90	59	05.47
Donaldsonville, freight station, 50 feet south of, Texas and Pacific Rwy. main line, overhead crossing of St. Patrick street	30	05	54.1	90	59	21.9
Donaldsonville, 1.7 miles south of, second-class road crossing at trestle over small stream	30	05	12.1	90	59	35.9
Sugarhouse, 400 feet west of, center of track at road crossing	30	04	11.9	91	00	16.8
Belle Alliance, 0.75 mile north of, at Halfway station, road crossing, center of track	30	03	36.9	91	00	47.3
Belle Alliance station, 100 feet south of, road crossing	30	03	08.6	91	01	12.0
Belle Alliance, 1.1 miles south of, center of track; crossing signpost stands 15 feet west of track	30	02	14.8	91	01	32.1
Belle Alliance station, 1.8 miles south of, at sugarhouse, road crossing, center of track	30	01	37.3	91	01	38.9
Sweet Home sugarhouse, tramroad crossing, 550 feet south of, road crossing, center of track	30	00	47.5	91	01	38.9
Plattenville, 100 feet north of station, road crossing, center of main track	29	59	41.9	91	01	06.4

Geographic positions along highways.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Plattenville, Catholic Church, in south face at southeast corner, aluminum tablet stamped "Prim. Trav. Sta. No. 5, 1905"	29	59	29.4	91	01	23.3
Paincourtville, at junction of Bayou Lafourche and Lake Natchez roads, 400 feet northeast of Catholic Church, brick warehouse in northwest corner of intersection, east corner	29	59	38.3	91	03	14.9
Paincourtville, 0.6 mile north of, at Magnolia store, three corners, public T road to west, 60 feet southwest to corner of fence, 40 feet north to corner of store, 80 feet east to Bayou Lafourche levee	30	00	07.8	91	03	12.0
Paincourtville, 1 mile northwest of, Texas and Pacific and Southern Rwys. crossing, center of track	30	00	10.3	91	03	50.8
Paincourtville, about 2.5 miles northwest of, three corners, second-class road to south at bend of main road to northwest, 10 feet south to small bridge, 40 feet northeast to telephone pole	30	00	16.6	91	05	31.5
Paincourtville, about 3.75 miles northwest of, three corners, second-class T road to west, at bend of main road to north	30	00	24.2	91	06	32.0
Paincourtville, about 3.75 miles northwest of, second-class T road west at bend of main road to north, at corner of fence at northeast corner of intersection, iron post stamped "Prim. Trav. Sta. No. 6, 1905"	30	00	24.4	91	06	31.7
Grand Bayou, at old bridge site (1905), about 700 feet north of store, center of stream	30	00	59.5	91	07	51.1
Bayou Corne, center of bridge over	30	00	56.8	91	09	14.7
Small bayou, center of bridge over	30	00	48.7	91	09	56.9
Bayou Pierrepas, east end of bridge over	30	00	37.2	91	11	16.1
Bayou Pierrepas, bridge over, 0.6 mile southwest of, three corners, second-class T road west to Lake Natchez, 25 feet northeast to small bridge, 70 feet west to corner plank and wire fence, 35 feet east to hickory	30	00	16.2	91	11	40.8
Bayou Pierrepas, bridge over, 0.6 mile southwest of, three corners, second-class T road west to Lake Natchez, at fence corner at southwest corner of intersection, iron post stamped "Prim. Trav. Sta. No. 7, 1905"	30	00	16.1	91	11	41.6
Bayou Natchez, 0.75 mile east of, forks, second-class roads west to Bayou Natchez and north to Whitecastle Lumber Co.'s railroad, 35 feet south to live oak, 25 feet west to beech tree	30	00	42.8	91	13	04.0
Whitecastle Lumber Co.'s railroad, dwelling of Mr. Blanchard, on east edge of Lake Natchez, chimney at south end of dwelling	30	01	51.8	91	13	06.4

Geographic positions along Whitecastle Lumber Company's railroad.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Lake Natchez, east edge of, center of railroad, at edge of lake, 25 feet north to cypress tree with cross cut on face, 25 feet south to cypress tree with cross cut on face	30	02	42.4	91	13	07.3
Second-class road crossing, 1,400 feet north of end of long trestle	30	05	06.7	91	13	10.4
Branch railroad northwest, 250 feet east of, road crossing, center of track	30	06	20.8	91	12	42.3

Geographic positions along highways.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Richland lane, junction of railroads about 1,000 feet north of store, bridge over small stream crossing lane, center of bridge	30	06	56.1	91	11	27.7
Three corners, T road west, 20 feet west to field gate, 260 feet north to second-class T road east	30	08	06.0	91	10	44.1
Three corners, T road northwest, 30 feet west to corner of wire fence, 80 feet northeast to gum tree	30	08	34.2	91	10	26.5
Cane railroad crossing, center of track	30	09	19.5	91	09	57.8

Geographic positions along Texas and Pacific Railway between Whitecastle and Plaquemine.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Whitecastle station, 0.36 mile northwest of, road crossing, north rail	30	10	24.0	91	09	17.1
Whitecastle station, 0.36 mile northwest of, at crossing of Richland lane and Texas and Pacific Rwy., at corner of fence, 65 feet west of crossing, 30 feet south of center of Texas and Pacific Rwy., iron post stamped "Prim. Trav. Sta. No. 8, 1905"	30	10	23.9	91	09	17.8
Dorseyville station, 125 feet southeast of, road crossing, center of track	30	10	35.7	91	09	43.8
Dorseyville station, 1.2 miles northwest of, road crossing, center of track	30	11	22.7	91	10	30.5
Bayou Goula, 50 feet southeast of, road crossing, center of track	30	12	22.9	91	11	06.2
Bayou Goula, 1.6 miles northwest of, road crossing at platform at trestle No. 80 D, center of track	30	13	36.1	91	11	49.8
Seymourville station, 1.4 miles southeast of road crossing and cane railroad crossing Texas and Pacific Rwy., center of tracks	30	15	34.8	91	13	00.5
Seymourville, road crossing, center of tracks	30	16	42.1	91	13	40.6
Plaquemine station, 50 feet south of, main street crossing, center of main track	30	17	30.6	91	14	12.0
Plaquemine, in north face at northwest corner of Iberville Parish court-house, aluminum tablet stamped "Prim. Trav. Sta. No. 9, 1905"	30	17	33.8	91	14	01.3
Plaquemine, Catholic Church spire, United States engineers' triangulation point	30	17	31.97	91	14	02.85

BOSSIER, CADDO, AND DE SOTO PARISHES.

MANSFIELD AND SHREVEPORT QUADRANGLES.

The following geographic positions were obtained by primary traverse run by Sledge Tatum in 1905, incidental to the primary-traverse control in northeastern Texas. These positions form a portion of the circuit extending from Marshall, Tex., via Shreveport, La., to Atlanta, Tex., and are given on the United States standard datum.

MANSFIELD QUADRANGLE DE SOTO (PARISH).

Geographic positions along Texas and Pacific Railway near Greenwood.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Louisiana-Texas State line, road north and south	32	28	22.6	94	02	33.2
Road crossing	32	27	55.9	94	01	36.7
Road crossing	32	27	25.6	94	00	30.1
Cattle guard	32	27	10.2	93	59	05.0
Greenwood, 30 feet east of station, road crossing	32	26	56.0	93	58	24.7
Greenwood, 600 feet east of station, in concrete abutment, Coast and Geodetic Survey bench-mark tablet	32	26	54.9	93	58	18.2
Greenwood, 0.25 mile east of, 36 feet south of track, east side of cattle guard, iron post	32	26	53.4	93	58	11.4
Road crossing	32	26	53.1	93	57	13.2
Missouri, Kansas and Texas Rwy. crossing	32	26	39.6	93	56	16.4

Geographic positions along Missouri, Kansas and Texas Railway between Flourney and Jewella.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Flourney flag station, road crossing	32	26	52.2	93	54	04.8
Cattle guard, 38 feet south of track, iron post stamped "Prim. Trav. Sta. No. 117"	32	27	01.0	93	52	30.2
Road crossing	32	27	26.8	93	50	33.2
Jewella flag station, road crossing	32	28	19.5	93	47	47.6
Shreveport, near Kansas City Southern Rwy. crossing	32	29	34.9	93	45	36.2
Cattleguard, Kansas City Southern Rwy., 40 feet east of track, iron post stamped "Prim. Trav. Sta. No. 153"	32	29	57.5	93	47	16.6

SHREVEPORT QUADRANGLE (BOSSIER AND CADDO PARISHES).

Geographic positions along Kansas City Southern Railway, Shreveport to Bloomsburg.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Road crossing	32	31	22.6	93	49	04.8
Milepost 552, road crossing	32	32	35.5	93	50	43.8
Milepost 550	32	33	46.3	93	52	11.8
Milepost 549, road crossing 500 feet north of	32	34	24.5	93	52	59.4
Blanchard, 1,900 feet north of, 35 feet west of track, at south side of wagon road crossing, iron post stamped "Prim. Trav. Sta. No. 184"	32	35	12.4	93	53	43.1
Road crossing	32	37	04.0	93	54	46.2
Milepost 544, road crossing	32	38	05.4	93	55	32.3
Milepost 542	32	39	21.4	93	56	54.6
Thirty-six feet east of track, 340 feet north of road crossing, iron post stamped "Prim. Trav. Sta. No. 213"	32	40	39.3	93	57	15.2
Mooringsport, 100 feet north of station, road crossing	32	41	37.7	93	57	27.6
Caddo flag station, road crossing, 30 feet west of track, south of road, iron post stamped "Prim. Trav. Sta. No. 234"	32	45	28.9	93	58	25.8
Ananias flag station, road crossing	32	44	40.1	93	58	14.7
Milepost 532	32	47	52.5	93	58	46.3
Milepost 530	32	49	37.1	93	58	51.8
Road crossing	32	51	40.5	93	59	09.1
Vivian station, 500 feet south of, road crossing, 30 feet west of track, on east side of wagon road, iron post stamped "Prim. Trav. Sta. No. 259"	32	52	15.4	93	59	07.4
Milepost 524	32	54	38.9	93	58	50.3
Myrtistown, 32 feet west of track, 8 feet south of milepost 523, iron post stamped "Prim. Trav. Sta. No. 273"	32	55	23.4	93	59	23.1

MICHIGAN.

PRIMARY TRAVERSE.

LIVINGSTON COUNTY.

HOWELL QUADRANGLE.

The line begins at an adjusted position near the northwest corner of the Milford quadrangle, follows highways west and south near the borders of the quadrangle, and is tied to the end of a spur line at Anderson run in 1901 by Mr. G. T. Hawkins.

Geographic positions along highways.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
T. 4 N., R. 6 E., corner secs. 19, 20, 29, and 30, crossroads	42	43	17.9	83	46	59.3
T. 4 N., R. 6 E., west corner secs. 19 and 30	42	43	15.6	83	48	08.5
T. 4 N., R. 5 E., east corner secs. 24 and 25	42	43	15.2	83	48	08.3
T. 4 N., R. 5 E., corner secs. 23, 24, 25, and 26, crossroads	42	43	13.0	83	49	18.9
T. 4 N., R. 5 E., corner secs. 22, 23, 26, and 27, T road east	42	43	10.5	83	50	29.6
T. 4 N., R. 5 E., corner secs. 21, 22, 27, and 28, crossroads	42	43	08.2	83	51	40.6
T. 4 N., R. 5 E., corner secs. 21, 22, 27, and 28, 20 feet southwest of; iron post stamped "Prim. Trav. Sta. No. 16, 1905, Mich."	42	43	05.5	83	52	51.4
Schoolhouse, four corners	42	43	03.9	83	54	02.8
T. 4 N., Rs. 4 and 5 E., corner secs. 19, 30, 25, and 24	42	43	00.5	83	55	08.9
Railroad, T road east 0.25 mile west of	42	43	10.8	83	56	55.2
Cemetery, crossroads 0.25 mile west of	42	42	30.0	83	58	04.9
Autcliff (E. D.), house, 140 feet west of; on west side north-south road; iron post stamped "Prim. Trav. Sta. No. 17, 1905, Mich."	42	42	14.7	83	59	49.8
T. 4 N., R. 4 E., corner secs. 28, 29, 32, and 33, crossroads	42	42	02.2	83	59	49.0
T. 4 N., R. 4 E., south corner secs. 32 and 33, T road north	42	41	09.6	83	59	46.4
T. 3 N., R. 4 E., quarter corner between secs. 8 and 9, crossroads	42	39	55.2	83	59	41.6
T. 3 N., R. 4 E., corner secs. 16, 17, 20, and 21, crossroads	42	38	35.7	83	59	38.6
T. 3 N., R. 4 E., quarter corner between secs. 28 and 29, crossroads	42	37	17.5	83	59	36.7
Corner secs. 4, 5, 32, and 33, 1,025 feet north of, east side of north-south road, large oak across road bears S. 80° W., distant 46 feet; iron post stamped "Prim. Trav. Sta. No. 18, 1905, Mich"	42	36	09.0	83	59	34.5
Tps. 2 and 3 N., R. 4 E., corner secs. 4, 5, 32, and 33, crossroads	42	35	58.9	83	59	34.7
T road north, large house 100 feet northwest, large barn 150 feet northeast	42	35	21.9	84	00	22.1
T. 2 N., R. 4 E., quarter corner between secs. 6 and 7, T road south	42	34	56.2	84	01	13.4
T. 2 N., R. 4 E., quarter corner between secs. 7 and 18, T road east	42	34	03.7	84	01	09.0
Church and store, crossroads	42	32	45.7	84	01	21.4
T road east	42	32	06.9	84	01	07.9
Tps. 1 and 2 N., R. 4 E., quarter corner between secs. 6 and 31, crossroads	42	30	36.3	84	01	08.7
Quarter corner between secs. 6 and 7, T road east at, 40 feet southeast of, on east side of north-south road; iron post stamped "Prim. Trav. Sta. No. 19, 1905, Mich."	42	29	46.9	84	01	04.6
T. 1 N., R. 4 E., quarter corner between secs. 7 and 18, crossroads	42	28	54.5	84	01	00.4
Anderson station	42	28	02.6	84	00	40.2

LAPEER, MACOMB, AND OAKLAND COUNTIES.

LEONARD QUADRANGLE.

This line starts from an adjusted position near the northwest corner of the Rochester quadrangle and follows highways north to Oxford, thence along the Michigan Central Railway to Hunters Creek, thence east and south along highways to an adjusted position near the northeast corner of the Rochester quadrangle.

Geographic positions along highways.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
T. 4 N., R. 10 E., quarter corner between secs. 14 and 23, crossroads	42	45	06.5	83	14	48.7
Orion, crossroads 1 mile south of	42	46	02.5	83	14	22.3
Orion, crossroads at Commercial Hotel	42	47	04.1	83	14	24.0
Orion, railway crossing under track 1 mile northwest of	42	47	49.6	83	14	47.8

Geographic positions along Michigan Central Railway, Oxford to Hunters Creek.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Oxford, crossing Michigan Central Rwy. and Pontiac, Oxford and Northern R. R.	42	49	39.4	83	15	49.4
Oxford, railway crossing 1.25 miles north of	42	50	32.5	83	16	30.1
Thomas, 0.75 mile south of, railway crossing east and west	42	52	07.5	83	17	41.5
Thomas, 0.25 mile north of, railway crossing east and west, on county line	42	52	59.6	83	17	51.0
Thomas, 0.25 mile north of, on west edge of railway right of way, north side of east-west road; iron post stamped "Prim. Trav. Sta. No. 6, 1905, Mich."	42	52	59.9	83	17	51.4
Milepost 59, east-west road crossing 800 feet south of	42	54	43.5	83	18	09.1
Milepost 58, east-west road crossing overhead 800 feet south of	42	55	35.1	83	18	03.9
Matamora, crossing just north of station	42	56	28.4	83	17	17.4
Matamora, 1 mile north of, east-west crossing	42	57	21.7	83	17	02.2
Township line, east-west road crossing on	42	58	15.3	83	17	07.9
Hunters Creek, east-west road crossing	42	59	07.0	83	17	33.4

Geographic positions along highways near north and east borders of quadrangle.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
T. 7 N., R. 10 E., corner secs. 27, 28, 33, and 34, T road north	42	59	07.9	83	16	53.0
T. 7 N., R. 10 E., corner secs. 26, 27, 34, and 35, crossroads	42	59	09.1	83	15	42.5
Corner secs. 26, 27, 34, and 35, 120 feet east and 20 feet north of, north side of east-west road, iron post stamped "Prim. Trav. Sta. No. 7, 1905, Mich."	42	59	09.1	83	15	40.8
T. 7 N., R. 10 E., corner secs. 25, 26, 35, and 36, crossroads	42	59	11.0	83	14	32.3
T. 7 N., R. 10 E., corner secs. 25 and 36, T road west at east corner of	42	59	12.7	83	13	21.3
T. 7 N., R. 11 E., corner secs. 28, 29, 32, and 33, three corners	42	59	16.0	83	11	00.3
T. 7 N., R. 11 E., corner secs. 27, 28, 33, and 34, T road east	42	59	17.9	83	09	50.2
T. 7 N., R. 11 E., corner secs. 27, 28, 33, and 34, 875 feet east of, on south side of east-west road; iron post stamped "Prim. Trav. Sta. No. 8, 1905, Mich."	42	59	18.1	83	09	38.5
T. 7 N., R. 11 E., corner secs. 26, 27, 34, and 35, T road east	42	59	20.3	83	08	39.5
T. 7 N., R. 11 E., corner secs. 25, 26, 35, and 36, crossroads	42	59	21.8	83	07	29.0
T. 7 N., R. 12 E., west corner secs. 30 and 31, T road east	42	59	24.7	83	06	18.2
T. 7 N., R. 12 E., corner secs. 29, 30, 31, and 32	42	59	26.9	83	05	08.5
T. 7 N., R. 12 E., south corner secs. 33 and 34, crossroads	42	58	43.1	83	02	44.2
T. 7 N., R. 12 E., south corner secs. 33 and 34, west side of north-south road 600 feet south of, 50 feet southeast of E. Harrington's house; iron post stamped "Prim. Trav. Sta. No. 9, 1905, Mich."	42	58	37.1	83	02	44.1
T. 6 N., R. 12 E., corner secs. 3, 4, 9, and 10, crossroads	42	57	46.8	83	02	51.8
T. 6 N., R. 12 E., corner secs. 9, 10, 15, and 16, crossroads	42	56	54.6	83	02	49.1
T. 6 N., R. 12 E., corner secs. 15, 16, 21, and 22, crossroads	42	56	05.0	83	02	46.4
T. 6 N., R. 12 E., corner secs. 21, 22, 27, and 28, crossroads	42	55	11.2	83	02	42.8
T. 6 N., R. 12 E., corner secs. 27, 28, 33, and 34, crossroads	42	54	18.7	83	02	40.0
Tps. 5 and 6 N., R. 12 E., corner secs. 3, 4, 33, and 34, crossroads	42	53	21.7	83	02	36.5
Almont, 3 miles south of, 1,050 feet south of Karl Schroder's house, 250 feet south of fork to southeast, east side of north-south road; iron post stamped "Prim. Trav. Sta. No. 10, 1905, Mich."	42	52	35.1	83	02	32.0
T. 5 N., R. 12 E., corner secs. 3, 4, 9, and 10, crossroads	42	52	25.2	83	02	31.8
T. 5 N., R. 12 E., corner secs. 9, 10, 15, and 16, crossroads	42	51	33.3	83	02	28.9
T. 5 N., R. 12 E., corner secs. 15, 16, 21, and 22, T road north	42	50	41.4	83	02	26.9
T. 5 N., R. 12 E., corner secs. 27, 28, 33, and 34, crossroads	42	48	56.9	83	02	22.8
T. 5 N., R. 12 E., south corner secs. 33 and 34, T road north	42	48	04.0	83	02	21.1
T 4 N., R. 12 E., north corner secs. 3 and 4, T road south	42	48	04.0	83	02	19.8
T. 4 N., R. 12 E., corner secs. 3, 4, 9, and 10, crossroads	42	47	07.9	83	02	18.4
T. 4 N., R. 12 E., corner secs. 9, 10, 15, and 16, crossroads	42	46	15.2	83	02	16.5
T. 4 N., R. 12 E., corner secs. 15, 16, 21, and 22, crossroads	42	45	22.8	83	02	14.7

LIVINGSTON AND OAKLAND COUNTIES.

MILFORD QUADRANGLE.

This line starts from an adjusted position at New Hudson, follows highways west, north, and east near the borders of the quadrangle, and is tied to an adjusted position near the northwest corner of the Pontiac quadrangle.

Geographic positions along highways.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
New Hudson station	42	30	31.4	83	38	43.4
County line, road south ½ mile east of	42	30	58.8	83	39	34.7
County line, north road on	42	31	01.4	83	40	14.4
Church, crossroads	42	31	03.4	83	41	25.4
Tps. 1 and 2 N., R. 6 E., quarter corner secs. 3 and 34	42	30	59.5	83	43	11.1
T. 2 N., R. 6 E., quarter corner between secs. 27 and 34, three corners	42	31	52.1	83	43	14.8
T. 2 N., R. 6 E., corner secs. 21, 22, 27, and 28, crossroads	42	32	44.0	83	43	53.6
T. 2 N., R. 6 E., corner secs. 20, 21, 28, and 29, T road east	42	32	41.3	83	45	04.6
Schoolhouse, five corners	42	34	53.8	83	45	12.2
East side of north-south road, Mr. Bueck's house bears northwest, distant 250 feet, and his barn bears northeast, distant 100 feet; iron post stamped "Prim. Trav. Sta. No. 13, 1905, Mich."	42	36	31.5	83	44	53.2
Schoolhouse, T road west	42	37	05.1	83	45	00.6
Hartland, crossroads 1.5 miles south of	42	37	58.2	83	45	10.8
Hartland, T road east at hotel	42	39	24.1	83	45	16.4
T. 3 N., R. 6 E., corner secs. 4, 5, 8, and 9, crossroads	42	40	36.4	83	45	37.7
T. 4 N., R. 6 E., south corner secs. 32 and 33, T road north	42	41	34.5	83	45	42.6
T. 4 N., R. 6 E., corner secs. 28, 29, 32, and 33, crossroads	42	42	27.5	83	45	45.9
T. 4 N., R. 6 E., corner secs. 20, 21, 28, and 29, crossroads	42	43	20.3	83	45	49.1
T. 4 N., R. 6 E., corner secs. 16, 17, 20, and 21, crossroads	42	44	12.8	83	45	52.1
T. 4 N., R. 6 E., corner secs. 16, 17, 20, and 21, 300 feet east of, on south side of east-west road; iron post stamped "Prim. Trav. Sta. No. 14, 1905, Mich."	42	44	12.8	83	45	48.1
T. 4 N., R. 6 E., corner secs. 15, 16, 21, and 22, crossroads	42	44	15.0	83	44	40.1
T. 4 N., R. 6 E., corner secs. 14, 15, 22, and 23, crossroads	42	44	17.3	83	43	29.7
T. 4 N., R. 6 E., corner secs. 13, 14, 23, and 24, T road west	42	44	19.5	83	42	17.2
T 4 N., R. 6 E., quarter corner between secs. 13 and 14, T road east	42	44	45.9	83	42	18.6
County line, crossroads	42	44	40.4	83	41	07.0
County line, crossroads 1 mile east of	42	44	21.7	83	39	56.6
On south side of road 1 foot north of cemetery fence and 30 feet east of cemetery gate; iron post stamped "Prim. Trav Sta. No. 15, 1905, Mich."	42	44	18.4	83	38	47.8
Rose Center, railway crossing north of station	42	43	53 7	83	37	03.4
T. 4 N., R. 7 E., quarter corner between secs. 14 and 23, T road south	42	44	28.6	83	35	48.9
T. 4 N., R. 7 E., quarter corner between secs. 13 and 24, crossroads	42	44	30.5	83	34	37.8
T. 4 N., R. 7 E., east sixteenth corner secs. 13 and 24	42	44	32.2	83	34	02.6
T. 4 N., R. 8 E., center sec. 20, T road north	42	44	09.5	83	32	13.2

OAKLAND COUNTY.

PONTIAC QUADRANGLE.

The following geographic positions were determined by primary traverse in 1905 by George T. Hawkins, topographer. The line starts from a point near the northeast corner of the quadrangle, follows highways west and south, and connects with an adjusted position on a line determined by J. R. Ellis in 1903.

Geographic positions along highways.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
T road west	42	44	08.0	83	14	41.5
T. 4 N., R. 10 E., near center sec. 27, road south	42	43	58.0	83	15	48.0
T. 4 N., R. 10 E., near northwest corner sec. 28, T road south	42	44	11.0	83	17	18.0
T. 4 N., R. 10 E., near northwest corner sec. 29, T road east; sign "Orion 7 miles"	42	44	09.3	83	18	29.6
T. 4 N., R. 10 E., quarter corner west side sec. 30, elbow north and west.	42	43	41.5	83	19	48.3
T. 4 N., R. 9 E., corner secs. 25, 26, 35, and 36, crossroads	42	43	10.8	83	20	57.8
T. 4 N., R. 9 E., corner secs. 26, 27, 34, and 35	42	43	08.7	83	22	09.2
T. 4 N., R. 9 E., corner secs. 27, 28, 33, and 34	42	43	06.8	83	23	20.3
Junction of east-west road with northwest-southeast pike	42	43	03.7	83	24	56.4
T road south	42	43	22.8	83	27	42.5
T. 4 N., R. 8 E., corner secs. 22, 23, 26, and 27, T road north	42	43	46.9	83	29	13.4
T. 4 N., R. 8 E., corner secs. 21, 22, 27, and 28, 0.25 mile west of, on west side of north-south road, 40 feet north of T road east, 200 feet south of elbow west and south, 0.25 mile west of W. E. Neal's house and same distance west of C. F. Cross's houes, 1 mile west of Andersonville, iron post stamped "Prim. Trav. Sta. No. 11, 1905"	42	43	43.5	83	30	42.3
Tps. 3 and 4 N., R. 8 E., between secs. 4 and 33, T road north	42	41	59.9	83	30	47.2
Crossroads north, southwest, and southeast	42	41	01.8	83	30	51.9
T. 3 N., R. 8 E., in sec. 15, four corners	42	40	04.5	83	29	18.8
T. 3 N., R. 8 E., T road north on south side of sec. 22	42	38	31.9	83	29	39.0
T. 3 N., R. 8 E., quarter corner between secs. 27 and 34, crossroads	42	37	38.8	83	29	30.3
T. 3 N., R. 8 E., quarter corner south side sec. 34, T road north	42	36	47.2	83	29	27.7
Bradley (J.) house, 300 feet southeast of, 3 feet from north-south picket fence; iron post stamped "Prim. Trav. Sta. No. 12, 1905"	42	36	30.2	83	29	30.3
T. 2 N., R. 8 E., in center sec. 10, T road north, in west part of Commerce	42	35	26.6	83	29	26.5
Commerce, in east part of, T. 2 N., R. 8 E., quarter corner between secs. 10 and 11, at crossroads	42	35	27.6	83	28	51.3
T. 2 N., R. 8 E., corner secs. 14, 15, 22, and 23, T road north	42	34	09.5	83	28	45.5
T. 2 N., R. 8 E., corner secs. 22, 23, 26, and 27, elbow east and south	42	33	17.4	83	28	42.5
Cemetery, road west-south of	42	31	31.4	83	29	29.8
T. 1 N., R. 8 E., corner secs. 4, 5, 8, and 9, crossroads	42	30	31.0	83	30	59.4
Novi, crossing of Green River road and north-south road 2 miles west of	42	29	22.2	83	30	55.9

MACOMB AND OAKLAND COUNTIES.

ROCHESTER QUADRANGLE.

The following geographic positions were determined by primary traverse in 1905 by George T. Hawkins, topographer. The line starts from an adjusted position determined by J. R. Ellis in 1903, follows highways north, west, and south near the borders of the quadrangle, and is connected with a position on the same adjusted line as starting point.

Geographic positions along highways.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
T. 1 N., R. 12 E., corner secs. 10, 11, 14, and 15	42	30	24.6	83	00	25.1
T. 1 N., R. 12 E., corner secs. 2, 3, 10, and 11, crossroads	42	31	16.7	83	00	27.6
Tps. 1 and 2 N., R. 12 E., corner secs. 2, 3, 34, and 35	42	32	13.3	83	00	30.1
Tps. 1 and 2 N., R. 12 E., corner secs. 3, 4, 33, and 34, crossroads	42	32	10.9	83	01	46.0
T. 2 N., R. 12 E., corner secs. 27, 28, 33, and 34 crossroads	42	33	03.4	83	01	44.5
T. 2 N., R. 12 E., corner secs. 21, 22, 27, and 28 crossroads	42	33	55.9	83	01	46.9
T. 2 N., R. 12 E., corner secs. 15, 16, 21, and 22, T road west at schoolhouse	42	34	48.4	83	01	49.0
T. 2 N., R. 12 E., corner secs. 9, 10, 15, and 16, crossroads	42	35	41.2	83	01	51.2
Utica, 1.5 miles south of, at August Gash's residence, on west side of north-south road, 5 feet from fence; iron post stamped "Prim. Trav. Sta. No. 2, 1905"	42	36	21.2	83	01	53.6
Tps. 2 and 3 N., R. 12 E., corner secs. 2, 3, 33, and 34, T road north	42	37	31.8	83	01	56.8
T. 3 N., R. 12 E., corner secs. 27, 28, 33, and 34 crossroads	42	38	25.3	83	01	58.8
T. 3 N., R. 12 E., corner secs. 21, 22, 27, and 28, crossroads	42	39	17.4	83	02	00.5
T. 3 N., R. 12 E., corner secs. 15, 16, 21, and 22, crossroads	42	40	09.5	83	02	02.0

Geographic positions along highways—Continued.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
T. 3 N., R. 12 E., corner secs. 9, 10, 15, and 16, crossroads at Disco	42	41	01.6	83	02	04.3
T. 3 N., R. 12 E., corner secs. 3, 4, 9, and 10, crossroads	42	41	53.8	83	02	05.4
Tps. 3 and 4 N., R. 12 E., corner secs. 3, 4, 33, and 34, crossroads	42	42	48.7	83	02	07.5
T. 4 N., R. 12 E., corner secs. 27, 28, 33, and 34, T road east	42	43	40.3	83	02	10.2
T. 4 N., R. 12 E., 18 feet southeast of southeast corner sec. 21, two mail boxes at southeast corner of square, marked "Mary Keeler" and "Fred G. Bravnier," 36 feet from bench mark, iron post stamped "Prim. Trav. Sta. No. 3, 1905"	42	44	33.1	83	02	12.3
T. 4 N., R. 12 E., corner secs. 20, 21, 28, and 29	42	44	31.6	83	03	24.7
Mount Vernon crossroads, T. 4 N., R. 12 E., quarter corner between secs. 19 and 30	42	44	28.9	83	06	12.7
T. 4 N., R. 11 E., quarter corner between secs. 23 and 26, T road south.	42	44	26.3	83	07	34.7
T. 4 N., R. 11 E., corner secs. 22, 23, 26, and 27, crossroads	42	44	25.6	83	08	10.0
T. 4 N., R. 11 E., secs. 22, 23, 26, and 27, 100 feet west and 15 feet south of corner, iron post stamped "Prim. Trav. Sta. No. 4, 1905"	42	44	25.4	83	08	11.2
T. 4 N., R. 11 E., crossroads between secs. 21 and 28	42	44	23.6	83	09	41.8
T. 4 N., R. 11 E., corner secs. 19, 20, 29, and 30, crossroads	42	44	20.6	83	11	49.2
T. 4 N., Rs. 10 and 11 E., corner secs. 19, 30, 24, and 25, T road east	42	44	19.2	83	12	55.4
T. 4 N., R. 10 E., crossroads between secs. 23 and 24	42	44	33.0	83	14	07.5
T. 4 N., R. 10 E., in sec. 23, 660 feet north of T road west, in front of George Porritt's house, on west side of north-south road, iron post stamped "Prim. Trav. Sta. No. 5, 1905"	42	44	16.7	83	14	43.2
T road west	42	44	08.0	83	14	41.5
T. 4 N., R. 10 E., quarter corner between secs. 26 and 35, crossroads	42	43	22.1	83	14	34.2
T road west	42	42	30.8	83	14	33.0
Schoolhouse, road east	42	41	23.0	83	14	29.0
Schoolhouse, crossroads 0.75 mile south and 0.25 mile west of	42	40	41.2	83	14	46.1
Large brick house, three corners	42	39	38.4	83	14	52.6
Brick schoolhouse, crossroads	42	38	56.5	83	14	34.2
T. 3 N., R. 10 E., corner secs. 23, 24, 25, and 26, T road north	42	38	57.6	83	13	45.4
Auburn, T road south, 1 mile northeast of	42	38	47.5	83	12	38.1
T. 3 N., Rs. 10 and 11 E., corner secs. 25, 30, 31, and 36, crossroads	42	38	01.4	83	12	36.0
Tps. 2 and 3 N., Rs. 10 and 11 E., corner secs. 1, 6, 31, and 36, crossroads.	42	37	14.4	83	12	33.5
T. 2 N., Rs. 10 and 11 E., corner secs. 1, 6, 7, and 12, corssroads	42	36	16.8	83	12	30.8
Birmingham, 4 miles north of, T. 2 N., Rs. 10 and 11 E., corner secs. 1, 6, 7, and 12 bears N. 3° 30′ W., distant 420 feet; oak tree on west side of road bears N. 80° W., distant 55 feet, on east side of north-south road iron post stamped "Prim. Trav. Sta. No. 1, 1905"	42	36	12.4	83	12	30.5
T. 2 N., Rs. 10 and 11 E., corner secs. 7, 18, 13, and 12. T road east	42	35	23.4	83	12	28.6
T. 2 N., Rs. 10 and 11 E., corner secs. 13, 18, 19, and 24, crossroads	42	34	32.0	83	12	26.1
T. 2 N., Rs. 10 and 11 E., corner secs. 24, 25, 19, and 30, crossroads.	42	33	37.5	83	12	23.6
T. 2 N., Rs. 10 and 11 E., corner secs. 25, 30, 31, and 36, crossroads 0.5 mile east of Birmingham	42	32	47.9	83	12	21.2
Tps. 1 and 2 N., R. 10 E., corner secs. 1, 2, 35, and 36	42	31	52.0	83	13	26.5
T. 1 N., R. 10 E., corner secs. 1, 2, 11, and 12, crossroads	42	31	00.5	83	13	24.2
T. 1 N., R. 10 E., corner secs. 11, 12, 13, and 14	42	30	07.8	83	13	21.4

MISSISSIPPI.

PRIMARY TRAVERSE.

COPIAH, HINDS, MADISON, RANKIN, SIMPSON, AND WARREN COUNTIES.

BRANDON, EDWARDS, FLORENCE, JACKSON, RAYMOND, TERRY, AND VICKSBURG QUADRANGLES.

The following geographic positions were determined from primary traverse by J. R. Ellis in 1902 and 1903. The line between Vicksburg and Jackson was run and duplicated, giving a checked value for Jackson which was based on United States Mississippi River Commission triangulation station Trinity Church spire, as given on page 2805 in the report of the Chief of Engineers, United States Army, 1887. This line follows the Alabama and Vicksburg Railway. A spur line was run northward from Jackson along the Yazoo and Mississippi Valley Railroad to Pocahontas. A spur line was also run southward from Jackson, following the Illinois Central Railroad to the line between Hinds and Copiah counties. Another line was run eastward from Jackson along the Alabama and Vicksburg Railway to the range line between Rs. 3 and 4 E.

In 1905 C. B. Kendall, field assistant, extended lines around the borders of the Florence, Jackson, Raymond, and Terry 15′ quadrangles, starting at Pocahontas, tying to the positions at Bolton, county-line post near Crystal Springs and Brandon, and closing at Pocahontas.

BRANDON QUADRANGLE (RANKIN COUNTY).

Geographic positions along Alabama and Vicksburg Railway from Brandon station to T. 5 N., Rs. 3 and 4 E., secs. 7 and 12.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Road crossing north and south	32	17	28.6	89	58	39.3
T. 5 N., Rs. 3 and 4 E., quarter corner between secs. 7 and 12	32	17	25.4	89	56	15.4

Geographic positions along highways.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Brandon, 1 mile south of, forks of roads south and southwest, 30 feet north to double oak and signboard "Brandon 1 mile"	32	15	27.1	89	59	23.1
Brandon, four corners at church, street crossing	32	16	06.9	89	59	22.8
Brandon, Rankin County court-house, set in southwest corner of iron picket fence around, iron post stamped "Prim. Trav. Sta. No. 12, 1905"	32	16	22.5	89	59	13.6
Brandon, at northwest edge of, public roads north and west, 30 feet southwest to telephone pole, 20 feet northeast to plank walk	32	16	35.9	89	59	37.6
Brandon, Alabama and Vicksburg Rwy., center of main track opposite telegraph office	32	17	08.0	89	59	44.4
Brandon, 0.5 mile north of station; three corners, public T road to northwest, 40 feet northwest to gate, 50 feet south to persimmon tree	32	17	37.9	89	59	51.6
Brandon, 1.7 miles north of station, forks of roads north and northwest, 30 feet north to oak and signboard "Fanning 8 mi.," 20 feet west to oak	32	18	31.2	89	59	28.6
Brandon, 2.6 miles north of station, forks of second-class roads to east	32	19	07.4	89	59	56.7

EDWARDS QUADRANGLE (WARREN COUNTY).

Geographic positions along Alabama and Vicksburg Railway from Bovina station eastward.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Bovina station	32	21	04.2	90	44	06.5
Road crossing east and west	32	20	42.3	90	42	52.0
T. 6 N., R. 5 W., corner secs. 22, 23, 26, and 27	32	20	31.7	90	41	23.3
Smith station	32	20	21.1	90	40	24.9
Road crossing north and south	32	20	07.3	90	39	19.7
Road crossing north and south	32	19	54.6	90	38	06.3
Edwards, Main street, crossing of	32	19	46.3	90	36	21.7
Road crossing northwest and southeast	32	19	55.1	90	34	58.2
T. 6 N., Rs. 4 and 3 W., corner secs. 19, 24, 25, and 30	32	20	29.0	90	33	22.1
T. 6 N., R. 3 W., quarter corner between secs. 20 and 21	32	20	56.7	90	31	11.3

FLORENCE QUADRANGLE (HINDS, RANKIN, AND SIMPSON COUNTIES).

Geographic positions along highways.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Mohaffeys Ferry, Pearl River, 350 feet west of, three corners, public T road to south. 30 feet south to gate	31	59	44.5	90	13	32.7
Pearl post-office, 0.25 mile south of, at junction of Georgetown-Jackson and Pearl-Crystal Springs roads, at northeast corner of store of Barron & Co., iron post stamped "Prim. Trav. Sta. No. 8, 1905"	32	00	05.1	90	11	56.4
Pearl post-office, 1 mile southeast of, forks of roads south and east, 25 feet north to oak and signboard "Harrisville 7 miles," 30 feet west to oak	31	59	46.8	90	11	30.7
Top of low hill, forks of second-class road to northeast, 10 feet north to pine, 10 feet south to two pines	31	59	50.6	90	10	20.3
Forks in small hollow, second-class road to northwest, 10 feet southeast to pine, 30 feet southwest to oak	31	59	34.9	90	08	49.2
Harrisville, 3.2 miles northwest of, at east edge of pine forest, four corners, 25 feet south to corner of front-yard fence, 15 feet north to pine stump	31	59	20.8	90	07	33.8
Harrisville, 2 miles northwest of, at junction of Harrisville-Barrows Ferry and Harrisville-Mohaffeys Ferry roads, near southeast corner sec. 29, T. 2 N., R. 2 E., in angle at junction of roads, iron post stamped "Prim. Trav. Sta. No. 9, 1905"	31	58	47.9	90	06	41.3
Harrisville, 1.25 miles north of, four corners, public roads, 30 feet south to oak stump, 30 feet west to oak	31	59	10.4	90	05	43.3
Four corners, public crossroads, 40 feet north to dead pine, 10 feet southwest to dead pine	31	59	32.7	90	04	36.8
Big Creek, 0.6 mile west of, four corners, public crossroads, 30 feet northwest to signboard "Braxton 6.5 miles," 15 feet southeast to corner rail fence	31	59	26.9	90	03	51.6
Big Creek, 1,140 feet west of, on north edge of road, stake, T. 2 N., R. 2 E., corner secs. 23, 24, 25, and 26	31	59	24.7	90	03	27.3
Touchstone post-office, store of L. M. Kelly, 1,500 feet south of, T. 2 N., Rs. 2 and 3 E., corner secs. 13, 18, 19, and 24, at southwest corner of store, iron post stamped "Prim. Trav. Sta. No. 10, 1905"	32	00	03.5	90	02	22.7
Touchstone post-office, 1,500 feet north of, T. 2 N., Rs. 2 and 3 E., corner secs. 13, 18, 19, and 24	32	00	18.1	90	02	22.1
Touchstone post-office, 1 mile north of, four corners second-class east-west crossroads, 10 feet southwest to corner of wire fence, 35 feet northeast to black gum	32	00	58.2	90	02	31.6
Big Creek, center of bridge over	32	01	34.1	90	03	06.1
Rexford, 1 mile southeast of, forks of roads north and northeast, 15 feet south to oak, 15 feet west to oak	32	02	05.0	90	03	19.7
Rexford, 1.25 miles northeast of, Tps. 2 and 3 N., R. 2 E., secs. 1, 2, 35, and 36, one-sixteenth corner east of Rankin-Simpson county line	32	02	55.5	90	03	06.4
Star, 2 miles southwest of, forks of roads south and west to pine, 50 feet east to pine	32	04	00.4	90	03	17.7
Star, 1 mile southwest of, at top of hill, three corners, second-class T road to west, 20 feet west to gate, 10 feet northeast to corner of old house	32	04	47.2	90	03	07.8
Star station, 700 feet west of, road crossing, center of main track Gulf and Ship Island R. R	32	05	34.9	90	02	47.2
T. 3 N., Rs. 2 and 3 E., secs. 7, 12, 13, and 18, corner of, 1.6 miles north of Star, second-class T road to east	32	06	26.1	90	02	19.2
T. 3 N., R. 3 E., sec. 6, southwest corner of; 2.25 miles north of Star, 2.7 miles south of Thomasville, in northwest corner of intersection of crossroads, iron post stamped "Prim. Trav. Sta. No. 11, 1905"	32	07	25.8	90	02	03.9
Thomasville, 1.7 miles south of, four corners, second-class crossroads, 10 feet north to corner post of fence	32	08	03.1	90	01	35.0
Thomasville, 0.25 mile west of, at old store, four corners, crossroads, 40 feet northwest to corner of old store, 40 feet northeast to oak	32	09	26.9	90	01	10.4
Pat post-office, 0.25 mile northeast of, four corners, 35 feet west to pine, 40 feet east to double pine	32	10	41.0	90	00	36.6
Tumballs Creek, east prong, center of bridge over	32	11	15.3	90	00	02.2
Tumballs Creek, 1.9 miles northeast of three corners, public T road to east, 40 feet south to oak, 50 feet east to oak	32	12	38.4	89	59	14.5
Brandon, 3 miles south of, three corners, T road to northwest, 30 feet west to corner of wire fence, 60 feet northeast to dead oak	32	13	55.6	89	59	18.8

Geographic positions along Illinois Central Railroad between Pearl and Byram.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Road crossing east and west	32	14	51.6	90	12	38.5
Pearl, road crossing east and west	32	13	12.2	90	13	12.2
Road crossing east and west	32	11	45.3	90	13	47.5
Byram station	32	10	44.7	90	14	41.4

Geographic positions along Alabama and Vicksburg Railway from Pearson eastward.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Pearson, road crossing	32	14	48.8	90	07	56.4
Road crossing north and south	32	14	33.1	90	06	47.4
Road crossing north and south	32	14	06.0	90	05	33.1
Road crossing north and south	32	14	09.5	90	04	22.5
Greenfield, road crossing east and west	32	14	53.9	90	03	13.7

JACKSON QUADRANGLE (HINDS, MADISON, AND RANKIN COUNTIES.)

Geographic positions along highways.

Station.	Latitude.			Longitude.		
	°	′		°	′	″
Union Church, 2.1 miles south of, forks of second-class road to south, 35 feet west to oak, 40 feet south to oak	32	20	03.4	90	00	47.3
Union Church, 1.4 miles south of, forks of roads north and northwest 30 feet northwest to double oak, 40 feet northeast to oak	32	20	47.6	90	01	04.0
Lucknow, 1.5 miles east of, Union Church, at southeast corner of, 300 feet northwest of four corners, iron post stamped "Prim. Trav. Sta. No. 13, 1905"	32	21	50.5	90	01	03.4
Union Church, 0.7 mile north of, forks, second-class road to east	32	22	30.1	90	01	06.2
Union Church, 2.1 miles north of, four corners public crossroads, 50 feet southwest to oak and signboard "Jackson 12.25 mi.," 15 feet west to oak stump	32	23	14.2	90	02	03.4
Pelahatchee Creek, center of iron bridge over	32	23	56.1	90	02	04.4
Pelahatchee Creek, 1.5 miles north of, T. 7 N., R. 3 E., secs. 31 and 32, section line between, three corners, T road to north	32	24	25.4	90	01	17.0
T. 7 N., R. 3 E., corner of secs. 29, 30, 31, and 32	32	24	48.8	90	01	16.7
Johnsons Ferry, 3.2 miles east of, four corners, crossroads, T. 7 N., R. 3 E., quarter corner between secs. 29 and 30, 40 feet northeast to oak pointer with + carved, 30 feet northwest to oak pointer with square (⌉) carved	32	25	15.0	90	01	16.7
Johnsons Ferry, 2 miles east of, forks of roads west and north, 10 feet north to oak, 30 feet southwest to live oak	32	25	36.5	90	02	37.9
Johnsons Ferry, 0.5 mile east of, forks of road east and south of log pen, 30 feet northeast to oak, 25 feet west to pine	32	25	42.6	90	03	32.4
Pearl River, Johnsons Ferry, top of bank at east landing of	32	25	48.5	90	04	09.8
Johnsons Ferry, 1.1 miles west of, three corners, T road to east, 12 feet west to double oak, 40 feet northeast to telephone pole	32	26	04.3	90	05	12.1
Madison station, 2 miles southeast of, three corners, T road to west, 30 feet northeast to oak, 30 feet southeast to hickory	32	26	46.9	90	05	22.9
Madison station, 1.5 miles east of, in southwest corner of intersection of crossroads, iron post stamped "Prim. Trav. Sta. No. 14, 1905"	32	27	52.2	90	05	30.0
Madison station, 0.5 mile northeast of, three corners, T road to north 10 feet north to small bridge, 12 feet southwest to telephone pole	32	27	52.7	90	06	24.9
Madison station, 200 feet south of, road crossing, center of main track Illinois Central R. R	32	27	40.3	90	06	56.7
Madison station, 1.7 miles west of, forks of road west and southwest, 30 feet northeast to two sweet gums, 70 feet southwest to telephone pole	32	28	19.5	90	08	25.3
Madison station, 2.25 miles west of, forks of roads west and northwest, 40 feet northwest to telephone pole, and signboard "Madison station 2 mi.," 30 feet northeast to oak	32	28	41.8	90	08	41.7
Small stream, center of bridge over	32	28	48.5	90	09	44.1
China Grove Church, 400 feet southeast of, at junction of Jackson-Canton and Madison Station-Pocahontas roads, set in sandstone slab at north edge of road, aluminum tablet stamped "Elevation 415, Prim. Trav. Sta. No. 15, 1905"	32	28	59.8	90	10	35.4
China Grove Church, 1.4 miles west of, at top of hill, four corners, second-class north-south road, 25 feet north to gate 30 feet south to oak	32	29	00.6	90	11	52.6
Robinsons Springs, 1.7 miles east of, three corners, T road to south, second-class road to east	32	29	19.3	90	12	35.3
Robinsons Springs, 0.5 mile east of, at white church, three corners, second-class T road to south, 60 feet southeast to corner of church, 15 feet south to oak	32	29	39.5	90	13	37.3
Robinsons Springs, 1.1 miles west of, forks of road at store, second-class road to southwest, 30 feet northeast to corner of store, 60 feet southwest to corner of fence	32	29	40.9	90	14	59.8

Geographic positions along Alabama and Vicksburg Railway near Jackson.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
T. 6 N., R. 1 E., corner secs. 29, 30, 31, and 32	32	19	37.1	90	13	43.2
Jackson, north-south road crossing 1 mile northwest of	32	19	05.9	90	12	38.0

Geographic positions along Illinois Central Railroad near Jackson.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Jackson station	32	18	01.3	90	11	30.6
Jackson, crossing of Illinois Central R. R., and Alabama and Vicksburg Rwy	32	17	54.9	90	11	30.0
T. 5 N., R. 1 E., corner of secs. 3, 4, 9, and 10	32	17	48.2	90	11	35.6
Road crossing east and west	32	16	19.3	90	12	26.3

Geographic positions along Alabama and Vicksburg Railway.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Road crossing east and west	32	16	31.6	90	09	59.2
Road crossing north and south	32	15	33.3	90	09	12.0
Rice, station board	32	15	59.0	90	02	18.7
Road crossing north and south	32	16	43.5	90	00	17.9

Geographic positions along Yazoo and Mississippi Valley Railroad in the vicinity of Cynthia.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Road crossing east and west	32	19	33.9	90	11	15.3
Road crossing northeast and southwest	32	20	24.3	90	11	54.1
T. 6 N., R. 1 E., corner secs. 16, 17, 20, and 21	32	21	19.3	90	12	37.4
Road crossing northeast and southwest	32	21	59.9	90	13	15.5
Road crossing north and south	32	23	09.8	90	14	01.4
Cynthia, road crossing	32	24	03.5	90	14	55.2

RAYMOND QUADRANGLE (HINDS COUNTY).

Geographic positions along Yazoo and Mississippi Valley Railroad from Greene Crossing to Hinds-Madison county line.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Greene Crossing, road east and west	32	26	12.5	90	16	00.3
Road crossing east and west	32	27	22.3	90	16	46.3
Hinds-Madison county line, crossing of	32	29	12.9	90	17	19.0
Tps. 7 and 8 N., R. 1 W., corner secs. 2, 3, 34, and 35	32	29	13.5	90	16	43.3

Geographic positions along highways.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Pocahontas station, road crossing 80 feet north of, center of main track Illinois Central R. R	32	28	19.3	90	17	16.9
Pocahontas, 1.75 miles west of, at bend of main road to north at gate, second-class road forks to west	32	28	25.8	90	17	44.5
Pocahontas, 1.75 miles west of, bridge over small stream 800 feet west of, second-class T road to south	32	28	47.4	90	18	30.8
Bogue Chitto Creek, 1 mile east of, four corners, 40 feet west to large live oak	32	28	48.2	90	20	19.2
Bogue Chitto Creek, bridge over, center of	32	28	59.7	90	21	14.1
Church, 300 feet south of, forks of road southeast and south, 30 feet southwest to oak tree	32	28	53.5	90	22	23.5
Lula Church, Hinds-Madison county line, center of road crossing	32	29	14.7	90	22	49.6
Lula Church, 300 feet north of, in angle at junction of Pocahontas-county line and Vicksburg-Canton roads, iron post stamped "Prim. Trav. Sta. No. 1, 1905"	32	29	17.6	90	22	50.6
Lula Church, 1.4 miles southwest of, at bend of main road to south, second-class T road to west thru farm lot, 40 feet northeast to dead peach tree, 25 feet south to wire fence	32	28	38.7	90	23	48.5
Lula Church, 1.75 miles west of, at forks of public road northeast and southwest, second-class road southeast at crossing of Madison-Hinds county line, county-line tree on east edge of road	32	29	14.6	90	24	34.1
Lula Church, 2.75 miles west of, forks of road north, second-class road northwest, 30 feet west to dead oak, 50 feet southeast to old dwelling	32	28	58.3	90	25	28.2
Brownsville, 1 mile north of, four corners, 15 feet south to two old gateposts	32	27	50.5	90	26	21.4
Brownsville, 1.75 miles northwest of, forks of road north and northwest, 60 feet west to dead oak tree, 40 feet south to corner of wire fence	32	28	14.2	90	26	49.4
Hinds-Madison county-line corner, forks of road north and west, 90 feet northwest to large oak, 30 feet north to sweet-gum tree	32	29	15.1	90	27	01.1
County-line corner, 1 mile west of, second-class T road north, 15 feet north to large dead oak, 50 feet west to willow	32	29	15.2	90	27	56.2
Orangeville post-office, 1 mile north of, T. 7 N., R. 3 W., near corner of secs. 1, 2, 11, and 12, at junction Coxs Ferry-Bolton road and T road east, iron post stamped "Prim. Trav. Sta. No. 2, 1905"	32	29	19.8	90	29	11.7
Orangeville Post-Office, second-class T road to east, 20 feet northeast to large oak, 50 feet southwest to small building	32	28	36.9	90	29	09.4
Orangeville, 0.25 mile east of, forks of road south and southeast, 30 feet west to wire fence	32	28	22.0	90	28	51.3
Orangeville, 1.6 miles south of, at top of hill, 0.25 mile south of small stream crossing, four corners, second-class crossroads, 30 feet north to oak stump	32	27	26.4	90	29	05.8
Coxs Creek, center of bridge over	32	26	36.9	90	29	06.1
Brownsville, 3 miles southwest of, forks of road southwest and southeast, center of triangle at, 30 feet south to cedar tree, 50 feet east to oak tree	32	25	40.5	90	29	06.2
Three corners, T road east at top of hill, 25 feet west to wire fence, 30 feet southwest to water oak	32	24	39.1	90	29	06.1
Bolton, 3.6 miles north of, four corners, crossroads, 25 feet east to gate.	32	23	30.7	90	28	58.4
Bolton, 2.5 miles north of, second-class T road southwest, 20 feet northwest to corner of wire fence	32	22	35.1	90	28	34.7
Bolton, 2 miles north of, forks of roads north and west, 25 feet southwest to oak tree on bank, 50 feet northwest to oak tree on bank	32	22	12.9	90	28	05.3
Bolton, at northeast corner of and inside of foundation to city water tower, iron post stamped "Prim. Trav. Sta. No. 3, 1905"	32	20	52.8	90	27	41.1
Bolton station, center of main track opposite telegraph office	32	20	50.2	90	27	29.1
Bolton, 0.75 mile south of, forks of roads south, east, and west, 60 feet east to telephone pole, 80 feet west to telephone pole	32	20	07.6	90	27	38.3
Bolton, 1.1 miles south of, three corners, second-class T road to west 10 feet south to bridge, 30 feet east to double willow	32	19	37.5	90	27	33.8
Bolton, 2.7 miles south of, three corners, T road to west, 5 feet west to center of bridge	32	18	18.5	90	27	48.2
Bolton, 3.6 miles south of, forks of second-class road to west, 25 feet west to gate	32	17	36.3	90	27	37.7
Raymond, 1.25 miles northwest of, three corners, T road to north, center of triangle, 40 feet northeast to large oak, 50 feet west to oak	32	16	19.5	90	26	23.5
Raymond, 0.75 mile northwest of, three corners, T road to northeast, 30 feet west to front yard gate, 20 feet east to fence corner	32	16	04.3	90	25	53.2
Raymond, Hinds County court-house, at southwest corner of iron fence around, iron post stamped "Prim. Trav. Sta. No. 4, 1905"	32	15	53.7	90	25	25.8

Geographic positions along Alabama and Vicksburg Railway between Bolton station and Dixon.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Section corner (no numbers)	32	20	56.6	90	29	07.5
Bolton station	32	20	50.2	90	27	29.1
Road crossing north and south	32	21	03.1	90	25	45.3
T. 6 N., R. 2 W., corner secs. 15, 16, 21, and 22	32	21	22.9	90	23	58.9
Stone culvert, United States Coast and Geodetic Survey bench mark on	32	20	50.1	90	20	19.9
T. 6 N., R. 1 W., corner secs. 19, 20, 29, and 30	32	20	29.3	90	19	50.3
Road crossing northeast and southwest	32	20	02.6	90	17	40.3
Dixon, north-south road crossing	32	19	30.4	90	15	12.2

Geographic positions along highways.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Robinson Springs, 1.7 miles west of, forks of roads northwest and southwest, 30 feet southeast to old chinaberry tree	32	29	56.1	90	15	38.4
Pocahontas, 1.25 miles northeast of, second-class road to south at bend of main road to west, Madison-Hinds county line	32	29	14.0	90	16	14.2
Pocahontas, 1 mile north of, roads north and east, 100 feet south to oak, 60 feet northeast to telephone pole	32	29	14.0	90	16	49.2
Pocahontas, at southwest corner of Pocahontas Methodist Church, iron post stamped "Prim. Trav. Sta. No. 16, 1905"	32	28	26.4	90	17	11.9
Pocahontas station, 80 feet north of center of main track Illinois Central R. R	32	28	19.3	90	17	16.9

TERRY QUADRANGLE (COPIAH AND HINDS COUNTIES).

Geographic positions along Illinois Central Railroad from Terry to Hinds-Copiah county line.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Road crossing east and west	32	09	30.5	90	15	26.4
Road crossing east and west	32	07	13.8	90	16	15.3
Road crossing east and west	32	06	03.7	90	17	14.6
Terry station	32	05	38.8	90	17	38.0
Road crossing east and west	32	04	52.5	90	18	21.3
Road crossing east and west	32	04	02.3	90	19	05.3
Tps. 2 and 3 N., R. 1 W., corner secs. 5, 6, 31, and 32	32	02	56.3	90	19	52.8
Hinds-Copiah county line, crossing of	32	02	56.9	90	20	04.2

Geographic positions along highways.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Raymond, 1.9 miles south of, three corners, second-class T road to west, 30 feet north to small bridge	32	14	21.9	90	26	03.0
Raymond, 2.5 miles south of, at top of hill, four corners, second-class crossroads, 35 feet west to gate, 35 feet east to gate	32	13	45.3	90	25	54.5
Perch Creek, 0.8 mile south of, three corners, T road west, 35 feet north to small bridge, 30 feet southeast to corner of wire fence	32	12	47.9	90	26	15.0
Newmans Creek, 0.5 mile south of, at top of hill, three corners, second-class T road east, 30 feet east to corner of garden fence	32	12	13.4	90	26	33.4
Palestine, 1.5 miles west of, four corners, cross-roads, 40 feet north to oak tree on bank	32	11	10.6	90	26	44.2
Schoolhouse, forks at, public roads southeast and southwest, 35 feet south to B. T. Wade's mail box, 20 feet west to oak	32	10	23.5	90	26	50.1
Tallahala Creek, center of bridge over	32	09	19.1	90	26	34.1
Tallahala Creek, 0.5 mile south of, at top of hill, three corners, T road to east, 90 feet north to oak, 35 feet west to wire fence	32	08	55.2	90	26	17.0
Drygrove, store of J. W. Grantham & Co., in forks of road at southeast corner of store, iron post stamped "Prim. Trav. Sta. No. 5, 1905"	32	07	42.9	90	26	15.0

Geographic positions along highways—Continued.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Drygrove, 0.75 mile south of, three corners, second-class T road to east, 50 feet east to gate, 40 feet west to large cherry tree	32	07	04.4	90	25	48.3
Drygrove, 2.5 miles south of, second-class road to west, 10 feet west to gate	32	05	45.5	90	26	03.2
Mount Wade Church, four corners, 60 feet east to schoolhouse, 100 feet west to corner of store	32	05	08.3	90	25	42.4
Mount Wade Church, 1.5 miles south of, at top of hill, four corners, second-class crossroads	32	03	55.9	90	25	29.0
Little White Oak Creek, 0.6 mile south of, near county line, forks of roads north and northeast, 30 feet northeast to pine, 30 feet south to crooked pine	32	02	52.9	90	25	09.3
Whiteoak Creek, 0.9 mile north of, forks of roads west and north, 35 feet east to telephone pole, 60 feet southeast to oak	32	02	14.3	90	25	17.3
Whiteoak Creek, center of bridge over	32	01	34.0	90	25	32.9
Whiteoak Creek, 0.25 mile south of, forks of roads southeast and southwest, 40 feet south to pine, 30 feet west to sweet gum	32	01	21.9	90	25	21.6
Goddys Corners, 4 miles northwest of Crystal Springs, in triangle at junction of Gallatin-Raymond and Pine Bluff-Crystal Springs roads, iron post stamped "Prim. Trav. Sta. No. 6, 1905"	31	59	43.7	90	25	04.1
Goddys Corners, 1.1 miles east of, three corners, T road to south, 25 feet northeast to oak, 40 feet south to pine	31	59	48.8	90	23	50.5
Forks, second-class road to north	32	00	06.2	90	23	12.8
Crystal Springs, 1.75 miles north of, forks of roads north and west, telephone pole in triangle	32	00	08.5	90	22	36.4
Crystal Springs, 2.25 miles north of, forks of roads north and east	32	00	33.8	90	22	40.0
Three corners, T road southwest, 25 feet south to pine stump, 50 feet west to elm	32	01	03.5	90	22	19.5
Lockwood schoolhouse, 1 mile west of, four corners, second-class north-south crossroads, 10 feet northeast to mail box, 20 feet south to small pine	32	00	39.5	90	21	50.2
Lockwood schoolhouse, 2.1 miles north of, overhead road crossing, center of east track under	32	01	56.1	90	20	03.2
Hinds-Copiah county line crossing, center between tracks Illinois Central R. R	32	02	56.9	90	20	04.2
Crystal Springs, 1.5 miles north of, on Port Gibson road 100 feet east of bridge over Illinois Central R. R., at southwest corner of Lockwood schoolhouse, iron post stamped "Prim. Trav. Sta. No. 7, 1905"	32	00	26.2	90	20	49.1
Lockwood schoolhouse, 0.9 mile east of, three corners, second-class T road to north, 30 feet northwest to small bridge	32	00	31.1	90	19	52.3
Pilgrims' Rest Church, stake at center of north building line of, T. 2 N., R. 1 W., secs. 16 and 21, quarter corner between	32	00	15.1	90	18	34.3
Pilgrims' Rest Church, 200 feet east of, four corners, 50 feet southeast to oak, 25 feet northeast to telephone pole	32	00	16.9	90	18	34.7
Pilgrims' Rest Church, 0.5 mile southeast of, three corners, 30 feet northeast to corner of store, 35 feet southeast to dead oak	32	00	03.1	90	18	16.3
Mount Pleasant Church, 0.25 mile southeast of, forks of roads southeast and northeast, 20 feet southwest to oak, 35 feet northwest to small pine	31	59	12.7	90	16	57.8
Beechgrove Church post-office, 0.25 mile east of, four corners	31	59	33.6	90	15	30.6

VICKSBURG QUADRANGLE (WARREN COUNTY).

Geographic positions along Alabama and Vicksburg Railway, Vicksburg to Newman.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Vicksburg, Trinity Church spire	32	20	49.2	90	52	40.5
Overhead road crossing north and south	32	20	24.2	90	50	58.5
Beechwoods, road crossing	32	19	44.1	90	48	49.2
Overhead road crossing north and south	32	20	12.6	90	47	38.1
Newman, north-south road crossing	32	20	43.9	90	46	15.3
Road crossing north and south	32	20	50.7	90	45	29.3

MISSOURI.

PRIMARY TRAVERSE.

KNOX, MACON, MONROE, RANDOLPH, AND SHELBY COUNTIES.

ATLANTA, MACON, SHELBINA, AND SHELBYVILLE QUADRANGLES.

The following geographic positions were determined in 1905 by J. R. Ellis, assistant topographer. The line starts from a section corner near Laplata located by primary traverse in 1901, follows the borders of four 15-minute quadrangles, and is connected with points at Shelbina and Jacksonville also located in 1901 by primary traverse. Positions in northeastern Missouri previously published, based on Mississippi River Commission triangulation (see report of that commission for 1883, p. 37), agree in latitude with the United States standard, but longitudes are 1.4″ greater than those by the United States standard. Positions given herewith have been reduced to the United States standard datum.

ATLANTA QUADRANGLE (KNOX AND MACON COUNTIES).

Geographic positions along highways.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
T. 60 N., R. 14 W., corner secs. 17, 18, 19, and 20	39	59	57.9	92	29	36.2
T. 60 N., R. 14 W., in northeast corner of NW. ¼ sec. 20, in northeast corner of field at T road south, in top of concrete post, aluminum tablet stamped ' Prim. Trav. Sta. No. 1, 1905"	39	59	57.1	92	29	02.5
T. 60 N., R. 14 W., corner secs. 16, 17, 20, and 21, T road north, 24 feet south to cross on fence post	39	59	57.0	92	28	29.1
T. 60 N., R. 14 W., north corner secs. 21 and 22, T road north, 28 feet northwest to telephone pole, 33 feet northeast to cross on telephone pole	39	59	55.9	92	27	21.4
T. 60 N., R. 14 W., north corner secs. 22 and 23, T road south, 38 feet southwest to mail box, 32 feet southeast to telephone pole	39	59	54.8	92	26	13.6
T. 60 N., R. 14 W., south corner secs. 13 and 14, center of road at hedge fence north, 14 feet south to cross on fence post	39	59	54.0	92	25	05.6
Titus Creek, course south, center of iron bridge over	39	59	53.6	92	23	33.9
Near quarter corner, at southeast corner of field owned by R. J. Collins at T road west, iron post stamped " Prim. Trav. Sta. No. 2, 1905"	39	59	52.4	92	22	16.9
Road north, W. R. Collins's mail box	39	59	39.0	92	21	09.3
Knox-Macon county line, center of road	39	59	37.1	92	20	35.2
T road west, cross cut on telephone pole	39	59	23.0	92	19	26.9
T road south, 24 feet northeast to J. O. Bowers's mail box, 36 feet north to cross on board fence	39	59	21.6	92	18	02.4
Browning (Robert) residence, T road south, 600 feet west of 7 feet northwest to cross on fence post	39	59	59.8	92	16	46.2
De Moss (John) residence, T road west, just east of, 49 feet northwest to Joseph Porter's mail box, 16 feet northeast to post	39	59	56.5	92	15	55.5

Geographic positions along Wabash Railroad between Laplata and Macon.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Laplata station	40	01	27.2	92	29	22.1
T. 60 N., R. 14 W., corner secs. 17, 18, 19, and 20	39	59	57.9	92	29	36.2
T. 59 N., R. 14 W., quarter corner between secs. 5 and 8	39	56	26.8	92	29	10.0
Atlanta station	39	53	58.7	92	28	49.2
T. 59 N., R. 14 W., corner on township line, south side secs. 32 and 33	39	52	06.5	92	28	36.5
T. 58 N., R. 14 W., corner secs. 8, 9, 16, and 17	39	50	21.8	92	28	38.7
Tps. 57 and 58 N., township line between	39	46	49.9	92	28	36.4

MACON QUADRANGLE (MONROE, RANDOLPH, AND SHELBY COUNTIES).

Geographic positions along highways near east and south borders of quadrangle.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Clarence, Chicago, Burlington and Quincy R. R. station	39	44	33.5	92	15	30.0
Clarence, 120 feet south of Hannibal and St. Joseph R. R., in park, iron post stamped "Prim. Trav. Sta. No. 18, 1905"	39	44	32.4	92	15	30.0
T. 57 N., R. 12 W., corner secs. 16, 17, 20, and 21, T road west, 18 feet due west to center of small bridge	39	44	09.1	92	15	29.3
T. 57 N., R. 12 W., corner secs. 20, 21, 28, and 29, crossroads, 18 feet northwest to north end of small bridge, 3.9 feet northeast to arrow on gate	39	43	16.5	92	15	31.2
T. 57 N., R. 12 W., corner secs. 28, 29, 32, and 33, crossroads, 25 feet northwest to Ed. Ryan's mail box, 21 feet east to center of small bridge	39	42	23.8	92	15	33.2
T. 57 N., R. 12 W., southwest corner sec. 33, iron post stamped "Prim. Trav. Sta. No. 19, 1905," elevation 787 feet	39	41	31.5	92	15	34.7
T. 56 N., R. 12 W., corner secs. 4, 5, 8, and 9, crossroads, 9 feet west to center of small bridge, 18 feet south to west end of small bridge	39	40	41.8	92	15	33.8
Otter Creek Bridge, T road east just north of, 6 feet west to cross on board fence, 65 feet south to north end of bridge	39	39	51.4	92	15	35.2
Enterprise, at crossroads, T. 56 N., R. 12 W., southeast corner sec. 17, iron post stamped "Prim. Trav. Sta. No. 20, 1905," elevation 811 feet.	39	38	57.1	92	15	37.0
T. 56 N., R. 12 W., corner secs. 20, 21, 28, and 29, crossroads, stone	39	38	04.2	92	15	38.3
T. 56 N., R. 12 W., corner secs. 28, 29, 32, and 33, crossroads, 27 feet northeast to "791" painted on post, 30 feet northwest to cross on corner fence post	39	37	11.6	92	15	39.8
T. 56 N., R. 12 W., south corner secs. 32 and 33, T road north, Shelby-Monroe county line	39	36	19.0	92	15	41.5
Duncans Bridge, 1 mile north of, T road west, 21 feet east to cross on fence post, 29 feet northwest to cross on corner fence post	39	35	31.7	92	15	49.5
Duncans Bridge, in southeast corner of Ferd Wedd's yard, iron post stamped "Prim. Trav. Sta. No. 21, 1905," elevation 717 feet	39	34	32.2	92	15	49.0
Duncans Bridge, center	39	34	27.6	92	15	53.2
Cap Branch, center of bridge over	39	33	52.5	92	16	26.9
Cap Branch Bridge, 1 mile south of, center of small bridge at T road north	39	33	08.0	92	16	44.9
T. 55 N., R. 12 W., center sec. 19, stone	39	32	42.1	92	17	37.0
Ash post-office, 2.5 miles north of, 0.5 mile west of Monroe-Randolph county line, at T road north, in southeast corner of Ewing Alexander's field, nail in hickory tree bears S. 55° 30′ W., distant 17.2 feet, iron post stamped "Prim. Trav. Sta. No. 12, 1905"	39	32	17.7	92	18	44.8
T. 55 N., R. 13 W., quarter corner between secs. 26 and 27, stone	39	31	54.8	92	20	28.2
T. 55 N., R. 13 W., quarter corner between secs. 27 and 28, crossroads, 16 feet northeast to S. Kindell's mail box, 30 feet southeast to J. W. Manning's mail box	39	31	56.6	92	21	36.9
T. 55 N., R. 13 W., quarter corner between secs. 28 and 29, crossroads, 27 feet northeast to cross on telephone pole, 27 feet southeast to cross on corner fence post	39	31	58.0	92	22	44.6
T. 55 N., R. 13 W., quarter corner between secs. 29 and 30, T road south 27 feet southeast to cross on telephone pole	39	31	59.6	92	23	51.6
T. 55 N., R. 14 W., quarter corner between secs. 19 and 30, stone at crossroads, 1,000 feet east of	39	32	26.4	92	24	26.2
T. 55 N., R. 14 W., in northeast corner sec. 26, 2 miles north of Cairo, at crossroads, iron post stamped "Prim. Trav. Sta. No. 13, 1905"	39	32	28.3	92	26	19.8
Milepost 182, road crossing, 1,400 feet north of	39	33	49.0	92	27	38.3
Jacksonville station	39	35	17.2	92	28	13.9

Geographic positions along Wabash Railroad between Macon and Jacksonville.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Macon station, Wabash R. R	39	44	18.1	92	28	35.1
Macon, Hannibal and St. Joseph R. R. crossing	39	44	16.4	92	28	35.4
T. 57 N., R. 14 W., quarter corner between secs. 27 and 28	39	42	58.8	92	27	50.5
Road crossing east and west	39	40	48.0	92	28	32.4
Excello station	39	38	11.6	92	28	28.8
Tps. 55 and 56 N., corner secs. 3, 4, 33, and 34	39	36	28.5	92	28	08.8
Jacksonville station	39	35	17.2	92	28	13.9

Geographic positions along Hannibal and St. Joseph Railroad between Macon and Clarence.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Anabel station	39	44	45.1	92	20	03.0
T. 57 N., R. 13 W., corner secs. 10, 11, 14, and 15	39	45	01.1	92	19	52.3
Rs. 12 and 13 W., line between	39	44	38.8	92	17	39.
Clarence station	39	44	33.5	92	15	36.0

SHELBINA QUADRANGLE (MONROE AND SHELBY COUNTIES).

Geographic positions along highways near east and south borders of quadrangle.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Salt River, north end of bridge over	39	44	30.8	92	02	24.6
Shelbina, 1.5 miles north of, crossroads, 30 feet southeast to cross on telephone pole, 40 feet southwest to cross on telephone pole	39	43	07.0	92	02	14.4
Shelbina, Main street crossing Hannibal and St. Joseph R. R	39	41	37.1	92	02	23.5
Catholic cemetery, T road south just south of, 16 feet southwest to cross on corner fence post, 22 feet southeast to east end of box culvert.	39	40	56.3	92	02	04.2
T. 56 N., R. 10 W., corner secs. 8, 9, 16, and 17, Shelby-Monroe county line, 18 feet southwest to cross on black-oak tree	39	39	38.0	92	02	05.5
Shelby-Monroe county line, 1.5 miles south of, at T road east on Shelbina-Paris road, in southwest corner of pasture of William Tourney, nail in blaze on elm bears N. 33° 15′ E., distant 11.2 feet; nail in blaze on elm bears S. 25° 30′ E., distant 5.1 feet, iron post stamped "Prim. Trav. Sta. No. 8, 1905"	39	38	19.9	92	02	06.6
Caldwell (J. W.) residence, T road south just east of, 30 feet southwest to H. S. Witt's mail box, 16 feet southwest to arrow painted on telephone pole	39	37	00.3	92	01	17.7
Hawkins post-office, T road north about 1.75 miles west of, 27 feet south to cross on rail fence, 27 feet northwest to cross on corner fence post	39	35	26.2	92	01	15.3
Hawkins post-office, 1 mile west of, T road south, 33 feet southeast to cross on corner fence post, 30 feet west to north end of small bridge.	39	35	24.8	92	00	22.2
T. 55 N., R. 10 W., sec. 10, stone, T road north	39	33	55.2	92	00	24.6
T. 55 N., R. 10 W., corner secs. 9, 10, 15, and 16, 20 feet due west to northeast corner of garden fence	39	33	28.6	92	01	02.0
T. 55 N., R. 10 W., corner secs. 15, 16, 21, and 22, T road north, just east of, 38 feet northeast to cross on telephone pole, 37 feet northwest to cross on birch tree	39	32	36.3	92	00	55.0
T. 55 N., R. 10 W., T. road south, corner secs. 27, 28, 33, and 34	39	31	43.8	92	01	06.3
T. 55 N., R. 10 W., southeast corner sec. 28, 2.7 feet southeast to nail in large corner fence post, iron post stamped "Prim. Trav. Sta. No. 9, 1905'	39	30	51.8	92	01	08.6
T. 55 N., R. 10 W., north corner secs. 32 and 33, T road south, 27 feet southeast to cross on corner fence post, 30 feet west to center of small bridge	39	30	52.4	92	02	16.4
T. 55 N , R. 10 W., south corner secs. 29 and 30, stone, T road north	39	30	52.1	92	03	34.
T. 55 N , R 10 W., corner secs. 19, 20, 29, and 30, T road west, 28 feet southwest to cross on gatepost, 28 feet northwest to cross on gatepost.	39	31	44.4	92	03	22.0
T. 55 N., Rs. 10 and 11 W., corner secs. 19, 24, 25, and 30, stone	39	31	46.6	92	04	30.0
T 55 N., R 11 W., stone at center sec. 23, T road south	39	32	15.1	92	06	10.2
T. 55 N., R. 11 W., quarter corner between secs. 21 and 22, 0.25 mile west of, in southwest corner of W. J. Williams's pasture, stone at crossroads bears S. 35° 10′ W , distant 30.3 feet, iron post stamped ' Prim. Trav. Sta. No. 10, 1905"	39	32	17.4	92	07	36.2
Forest Grove Church, T road north 0.75 mile east and 0.25 mile south of, 18 feet south to cross on rail fence	39	32	20.1	92	09	16.9
T. 55 N., R 11 W., corner secs. 7, 8, 17, and 18, crossroads, 15 feet southeast to south end of tile culvert, 36 feet southwest to C. Sanders's mail box	39	33	41.1	92	10	08.4
T. 55 N., Rs. 11 and 12 W., corner secs. 7, 12, 13, and 18, stone, T road north	39	33	42.5	92	11	05.8
Woodlawn, 1 mile south of, in northeast corner of Oak Grove Church yard, cross cut on northeast corner of stone foundation to church bears S. 39° 15′ W., distant 77.3 feet, iron post stamped "Prim. Trav. Sta. No. 11, 1905"	39	33	48.7	92	12	30.7
Woodlawn, T road south 0.25 mile east of, 22 feet north to cross on fence post, 30 feet southeast to cross cut on corner fence post	39	34	42.2	92	12	25.2
Woodlawn, L crossroads 0.75 mile west of, stone	39	34	45.6	92	13	35.2
Woodlawn, T road south 2 miles west of, 11 feet south to west end of bridge, 30 feet west to center of small bridge	39	34	49.7	92	14	59.5
Duncans Bridge, center of	39	34	27.6	92	15	53.1

Geographic positions along Chicago, Burlington and Quincy Railroad between Clarence and Shelbina.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Milepost 56, north and south road crossing near	39	43	53.2	92	12	07.0
Lentner station	39	43	07.3	92	08	49.9
T. 57 N., R. 11 W., corner secs 20, 21, 28, and 29	39	43	14.8	92	08	49.3
T. 57 N., Rs. 10 and 11 W., corner secs. 30, 31, 36, and 25	39	42	16.0	92	04	18.7

SHELBYVILLE QUADRANGLE (KNOX AND SHELBY COUNTIES).

Geographic positions along highways near west border of quadrangle.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Perry schoolhouse, southwest corner of J. W. Inderman's field, iron post stamped "Prim. Trav. Sta. No. 3, 1905"	39	59	49.5	92	14	47.4
T road east, 40 feet southwest to "elevation 822" painted on mail-box post, 32 feet southeast to telephone pole	39	58	31.7	92	13	58.6
T road east, 33 feet northeast to cross on corner fence post, 33 feet southeast to cross on corner fence post	39	57	39.4	92	14	00.1
T. 60 N., R. 12 W., south corner secs. 33 and 34, Knox-Shelby county line, 5 feet due south to nail in top of fence post	39	57	13.3	92	14	00.8
T. 59 N., R. 12 W., corner secs. 3, 4, 9, and 10, center of road 27 feet north of hedge-fence line	39	56	21.7	92	14	02.9
T. 59 N., R. 12 W., corner stone to secs. 9, 10, 15, and 16, at crossroads at Cherrybox	39	55	30.2	92	14	04.0
T. 59 N., R. 12 W., corner stone to secs. 15, 16, 21, and 22, at crossroads	39	54	36.9	92	14	05.2
T. 59 N., R. 12 W., corner stone to secs. 21, 22, 27, and 28, crossroads at church	39	53	44.4	92	14	06.5
T. 59 N., R. 12 W., sec. 27, corner stone to southwest corner bears S. 42° 30′ W., distant 33.5 feet, iron post stamped "Prim. Trav. Sta. No. 14, 1905"	39	52	52.5	92	14	07.3
T. 59 N., R. 12 W., just east of south corner of secs. 33 and 34, 12 feet northeast to stone, 30 feet southeast to "820 elev." painted on fence	39	52	00.0	92	13	51.6
Hagers Grove, 1 mile north of, in southwest corner of school yard, iron post stamped "Prim. Trav. Sta. No. 15, 1905," elevation 797 feet	39	50	42.1	92	13	19.0
Hagers Grove, T road north in northeast part of, 21 feet west to guideboards. 35 feet southwest to "740" painted on telegraph pole	39	49	52.5	92	13	21.0
Hagers Grove, 0.5 mile south by 0.5 mile west of, in orchard at top of hill, iron post stamped "Prim. Trav. Sta. No. 16, 1905," elevation 769 feet	39	49	15.0	92	14	13.8
T. 58 N., R. 12 W., corner stone to secs. 21, 22, 27, and 28, near crossroads	39	48	29.9	92	14	15.0
T. 57 N., R. 12 W., north quarter corner to sec. 4, in southeast corner of field, near iron post stamped "Prim. Trav. Sta. No. 17, 1905," elevation 808 feet	39	46	45.3	92	14	52.9
T. 57 N., R. 12 W., north corner secs. 4 and 5, T road southeast, 33 feet southeast to E. E. Hopkins's advertisement, 42 feet southwest to guidepost	39	46	44.6	92	15	24.0
T. 57 N., R. 12 W., corner secs. 4, 5, 8, and 9, crossroads, 21 feet west to center of bridge 31 feet northeast to bench mark 813	39	45	54.1	92	15	25.0
Clarence, T road west at A. O. U. W. cemetery in north part of	39	45	01.8	92	15	27.6

Geographic positions along highways near north and east borders of quadrangle.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
T. 60 N., R. 12 W., corner secs. 15, 16, 21, and 22, T road south, at center of small bridge	39	59	50.2	92	13	57.3
T. 60 N., R. 12 W., corner secs. 14, 15, 22, and 23, at cross roads 34 feet northwest to cross on corner fence post, 30 feet southwest to cross on telephone pole	39	59	51.8	92	12	49.2
T. 60 N., R. 12 W., corner secs. 13, 14, 23, and 24, at T road south, 21 feet east to center of small bridge, 35 feet southeast to cross on corner fence post	39	59	53.4	92	11	42.6
T. 60 N., R. 12 W., stone to east corner secs. 13 and 24, at T road west, road jogs south 80 feet, then east again	39	59	54.7	92	10	32.9
T road south, 48 feet southwest to cross on corner fence post, 30 feet southeast to F. E. Browning's mail box	39	59	32.6	92	09	22.0
Plevna, T road north, about 1 mile north by 2 miles west of, 33 feet northeast to J. L. Saler's mail box, 42 feet northwest to corner of hedge fence	39	59	23.7	92	07	56.7
Plevna, 1 mile north by 1 mile west of, in northeast corner of J. W. Hayden's field at T road south, 3.5 feet southwest of corner fence post, iron post stamped "Prim. Trav. Sta. No. 4, 1905"	39	59	20.8	92	06	31.8
Plevna, 1 mile north and 0.25 mile west of, stone at crossroads	39	59	18.7	92	05	25.3
Little Fabins River, west end of bridge over	39	59	15.3	92	03	56.5
Mount Salem Church, 0.25 mile east of, T road north, 18 feet southeast to W. E. Anderson's mail box, 22 feet northeast to east end of small bridge	39	59	13.5	92	02	45.8
Mount Salem Church, 1.5 miles east of, at crossroads, stone	39	59	12.2	92	01	19.4
Newark, 1.5 miles southwest of, near southeast corner of yard to log house at forks of road on land of John Vaden, southeast corner of log house bears N. 79° 30′ W., distant 56.7 feet; nail in blaze on east face of white-oak tree bears S. 66° W., distant 49.7 feet; iron post stamped "Prim. Trav. Sta. No. 5, 1905"	39	59	12.8	91	59	40.2
T. 60 N., R. 10 W., corner secs. 26, 27, 34, and 35, stone to, at crossroads.	39	57	52.1	91	59	34.4
T. 60 N., R. 10 W., south corner secs. 34 and 35, 0.25 mile west of, Knox-Shelby county line, stone at T road	39	57	00.8	91	59	42.[illegible]
Shiloh Church, T road east, 14 feet east to cross on telephone pole, 34 feet southeast to corner of rail fence	39	55	34.5	92	00	06.2
T. 59 N., R. 10 W., center of sec. 15, T road north, 27 feet southeast to W. A. Smith's mail box, 20 feet south to J. E. Wilson's mail box	39	54	50.4	92	00	02.4
T. 59 N., R. 10 W., T road south, stone at center of sec. 16	39	54	51.2	91	01	10.1
T. 59 N., R. 10 W., center of sec. 21, in southeast corner of field of Mr. Bowers, 1.25 miles north of Bethel, southwest corner of J. H. Moore's residence bears N. 40° 40′ E., distant 117 feet, iron post stamped "Prim. Trav. Sta. No. 6, 1905"	39	53	58.6	92	01	11.6
Bethel, center of iron bridge over North River	39	52	31.3	92	01	25.2
Bethel, T road north 1 mile south of, 28 feet south to cross on board fence, 26 feet northwest to cross on telephone pole	39	51	48.4	92	01	31.5
T. 58 N., R. 10 W., secs. 4, 5, 8, and 9, T road west, 19 feet east to cross on corner fence post, 24 feet west to center of small bridge	39	50	56.8	92	01	50.5
T. 58 N., R. 10 W., corner secs. 8, 9, 16, and 17, crossroads, 18 feet west to center of small bridge, 21 feet south to C. G. Bowers's mail box	39	50	04.7	92	01	51.5
T. 58 N., R. 10 W., corner secs. 16, 17, 20, and 21, crossroads, 15 feet east to center of small bridge, 40 feet northwest to advertisement "1 mile to Shelbyville"	39	49	12.6	92	01	53.0
Shelbyville, crossing of Main and Jackson streets, southwest corner of court-house bears N. 28° 10′ E., distant 184 feet; northwest corner of Miller's hardware store bears S. 22° 30′ E., distant 41 feet	39	48	22.2	92	02	25.2
Shelbyville, 1 mile south of, center of steel bridge over Black Creek	39	47	32.9	92	02	25.1
Shelbyville, crossroads 2 miles south of, 30 feet northeast to cross on corner fence post, 25 feet southeast to Wilbur Simen's mail box	39	46	35.3	92	02	29.5
Shelbyville, 4 miles south of, in northwest corner of field of C. J. Anderson, at T road east, 1.5 feet southeast of corner fence post, iron post stamped "Prim. Trav. Sta. No. 7, 1905"	39	45	18.0	92	02	30.5

NORTH CAROLINA.

PRIMARY TRAVERSE.

SAMPSON COUNTY.

SALEMBURG QUADRANGLE.

The following geographic positions were determined by C. B. Kendall in 1905: The line starts from a position at the southwest corner of the Four Oaks quadrangle, follows highways south, east, and north near the borders of the Salemburg quadrangle, and is connected with a position at the southeast corner of the Four Oaks quadrangle.

Geographic positions along highways.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Church, forks of road, 60 feet southeast to hickory tree, 20 feet northeast to pine	35	16	03.7	78	34	10.7
T road east, 15 feet west to gate, 10 feet southeast to pine stump	35	15	02.8	78	33	21.6
Church, four corners, 20 feet northeast to oak, 40 feet south to oak	35	14	32.3	78	32	58.9
Forks of road, 50 feet west to persimmon, 10 feet east to fence corner	35	13	59.0	78	33	17.8
Forks of second-class road, 400 feet east of sandhill swamp, 200 feet north of sawmill	35	13	22.4	78	33	15.7
Dwelling, four corners, 20 feet west to fence corner, 30 feet northeast to pine	35	12	42.0	78	33	39.1
T road west, at end of lane, 10 feet southeast to fence corner, 10 feet southwest to fence corner	35	12	01.4	78	33	49.2
Four corners, at northeast corner of field, 20 feet southwest to fence corner	35	11	36.5	78	33	51.1
Hawley's store. four corners, 300 feet east of, 40 feet southeast to gate, 40 feet northeast to gate	35	10	23.6	58	33	05.2
Forks of road, 15 feet northeast to persimmon, 10 feet west to rail fence	35	08	52.3	78	32	58.8
Four corners, 40 feet southwest to oak, 20 feet north to dead oak	35	08	36.8	78	33	17.8
Yard fence, northwest corner of, at old store	35	07	53.5	78	32	33.0
Orange post-office, at northeast corner of, store of Charles Hall, iron post stamped "Prim. Trav. Sta. No. 24, 1905"	35	06	50.5	78	31	57.8
Williams mill, forks of road, 30 feet northeast to bridge, 30 feet southwest to pine	35	05	57.6	78	32	08.8
Four corners	35	05	12.9	78	32	40.4
Forks of road, 40 feet west to corner of garden	35	04	15.8	78	32	31.1
Forks of road just north of stream, 20 feet east to oak, 80 feet south to stream	35	03	05.7	78	32	50.8
Old Chance post-office, T road south 0.25 mile west of	35	02	52.8	78	33	10.2
Four corners, 20 feet west to oak, 5 feet northeast to oak	35	01	54.7	78	32	45.0
Four corners, 40 feet north to pine, 40 feet west to two oaks	35	01	00.2	78	32	50.6
Four corners, 30 feet east to oak, 10 feet southeast to pine	35	00	08.0	78	32	52.9
Forks of road, 300 feet southeast of house, 30 feet east to pine	34	59	25.4	78	33	02.5
Bethel Church, four corners, 20 feet northeast to oak painted "P.T."	34	58	42.3	78	33	12.3
Hayne post-office, 1 mile east of, at southwest corner of Bethel Church, iron post stamped "Prim. Trav. Sta. No. 25, 1905"	34	58	44.3	78	33	12.4
Sawmill, four corners, 10 feet south to corner of plank fence, 30 feet north to oak	34	58	52.1	78	32	08.7
Junction of roads, 40 feet west to sign "Fayetteville 22 mi. Dam 30 mi."	34	58	57.0	78	32	28.7
T road south, 30 feet south of pine and sign "Rosehorn 1¾ miles," 50 feet west to oak	34	58	24.0	78	30	24.9
Four corners, 20 feet southwest to pine, 20 feet north to pine	34	58	29.6	78	29	39.9
Four corners, 20 feet northwest to pine, 15 feet southwest to mail box	34	58	14.8	78	28	24.0
T road north, 25 feet northwest to gate, 25 feet northeast to paling fence	34	57	49.4	78	26	59.3
Four corners, 20 feet southeast to J. H. Faircloth's mail box, 60 feet northeast to pine	34	58	17.4	78	26	04.5
Clinton, 5.5 miles west of, southeast corner Concord Methodist Church, iron post stamped "Prim. Trav. Sta. No. 26, 1905"	34	58	59.7	78	24	58.6
Four corners, 30 feet south to pine stump, 40 feet north to plank fence	34	59	18.6	78	23	36.3
Great Coharie Creek, center of bridge over	34	59	38.9	78	22	45.8
T road south, 10 feet west to bridge, 30 feet north to gate	34	59	29.2	78	21	08.6
T road south, 25 feet southwest to double oak, 10 feet north to plank fence	34	59	37.0	78	20	25.5
Clinton, Sampson County court-house, flagstaff on cupola	34	59	52.0	78	19	23.8
Clinton, end of Atlantic Coast Line tracks, stop blocks, 100 feet east to station	34	59	45.0	78	19	25.8
Second-class road crossing	34	59	43.4	78	17	35 1
Second-class road crossing at new house and fork of road	34	59	33.6	78	16	12.8

Geographic positions along highways—Continued.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Mottenville, 0.25 mile west of, at junction of roads, iron post stamped "Prim. Trav. Sta. No. 27, 1905"	34	59	25.8	78	15	[illegible]
Four corners at southwest corner of clearing, 15 feet north to pine, 40 feet east to fence	35	00	30.7	78	15	[illegible]
Clinton, 4 miles northeast of, forks of road, 30 feet southeast to sweet gum, 40 feet north to pine	35	01	56.9	78	16	[illegible]
Second-class crossroads, 25 feet east to gate, 25 feet west to bridge	35	02	44.4	78	16	[illegible]
Second-class T road east, 10 feet south to mail box, 20 feet northeast to corner rail fence	35	03	41.0	78	15	[illegible]
T road west, 500 feet north of milepost "8 miles to Clinton," 30 feet west to oak, 30 feet southeast to fence corner	35	04	39.2	78	14	[illegible]
Forks of road, 10 feet northeast to Thornton and King's mail box, 30 feet east to plank fence	35	05	40.7	78	15	[illegible]
Four corners, 25 feet southwest to corner of garden, 15 feet east to post	35	06	11.1	78	16	[illegible]
Second-class T road west, 10 feet east to fence, 25 feet southwest to fence corner	35	07	36.3	78	16	[illegible]
Hobton, 5 miles southeast of, 11 miles north of Clinton, in northeast corner of intersection of roads, iron post stamped "Prim. Trav. Sta. No. 28, 1905"	35	08	07.1	78	15	[illegible]
T road north, 100 feet northeast to forks of road, 20 feet north to pine stump	35	08	40.1	78	14	[illegible]
Hobton, T road north, 3 miles east of, 15 feet west to corner of fence, 20 feet north to fence corner	35	09	40.0	78	14	[illegible]
Goshen Church, T road east, 1.5 miles southeast of, 15 feet east to gate, 30 feet north to W. B. Bayett's mail box	35	10	24.0	78	15	[illegible]
Goshen Church, forks of road, 50 feet south to door of church	35	11	12.8	78	15	[illegible]
Goshen Church, forks of road, 1 mile northwest of, 40 feet northeast to gum tree	35	11	19.9	78	17	[illegible]
T road south, 200 feet east to three corners at tobacco barn, 25 feet west to small bridge	35	12	08.0	78	18	[illegible]
Forks of second-class road to west	35	12	40.4	78	18	[illegible]
Three corners, 3 feet west to fence post, 30 feet northeast to post	35	13	08.4	78	18	[illegible]
Forks of road, 10 feet ~~east to rail fence, 20 feet west to small bridge~~	35	13	55.9	78	18	[illegible]
T road south, 0.25 mile east of Thornton's store and 300 feet east of Bayett Schoolhouse, 10 feet southeast to sign "Clinton 20 miles"	35	14	48.9	78	18	[illegible]

NORTH CAROLINA-SOUTH CAROLINA.

PRIMARY TRAVERSE.

CLEVELAND AND GASTON COUNTIES, N. C.; CHEROKEE AND YORK COUNTIES, S. C.

BELMONT, GAFFNEY, KINGS MOUNTAIN, AND SHELBY QUADRANGLES.

The following geographic positions were determined by C. B. Kendall, field assistant, in May, 1906. The line starts at Yorkville, located by primary traverse in 1905, follows the Carolina and Northwestern Railway to Gastonia, thence along the Southern Railway to Kings Mountain station, thence along highways to Patterson Springs, thence along the Southern Railway to Blacksburg, thence along highways, and is tied to a primary-traverse position near the northwest corner of the Sharon quadrangle.

Another line continues around the north, west, and south borders of the Gaffney quadrangle and is tied to a point near the northwest corner of the Sharon quadrangle.

BELMONT QUADRANGLE (GASTON COUNTY, N. C.; YORK COUNTY, S. C.).

Geographic positions along Carolina and Northwestern Railway between Yorkville and Gastonia.

Station.	Latitude.			Longitude.		
SOUTH CAROLINA.	°	′	″	°	′	″
Neely Manufacturing Co.'s cotton mills, public-road crossing over spur track	34	59	56.0	81	14	09.5
Milepost 25, second-class road crossing, 50 feet southeast of	35	00	40.1	81	14	28.7
Milepost 26, second-class road crossing 230 feet north of, center of track	35	01	21.5	81	15	08.5
Filbert station, Carolina and Northwestern Rwy., road crossing, center of track	35	02	57.5	81	14	59.6
Second-class road crossing, center of railroad track	35	03	39.1	81	14	11.5
Public-road crossing, 400 feet south of trestle over Allison Creek, center of track	35	03	56.5	81	13	31.2
Public-road crossing, 1 mile north of Allison Creek, center of track	35	05	01.8	81	13	35.4
Clover station, second-class road crossing, 0.75 mile south of	35	05	49.4	81	13	57.3
Clover station, road crossing 75 feet south of, center of track	35	06	39.3	81	13	34.8
Clover station, front face of store in Doctor Campbell's block opposite bronze tablet stamped "Prim. Trav. Sta. No. 1, 1906"	35	06	40.7	81	13	34.4
Milepost 35, second-class road crossing 1,300 feet south of	35	07	53.3	81	12	52.0
Milepost 36, public-road crossing at cotton factory	35	08	57.1	81	12	41.7
Bowling Green station, public-road crossing 500 feet southwest of	35	09	12.0	81	12	22.0
NORTH CAROLINA.						
North Carolina-South Carolina State line, second-class road crossing at	35	09	28.4	81	11	52.0
Crowders Creek, public-road crossing 700 feet southeast of trestle over	35	10	02.2	81	11	40.8
Crowders Creek, public-road crossing, one-half mile north of trestle over	35	10	26.0	81	11	46.1
Crowders station, in face of chimney at north end of residence of W. D. Gillem, bronze tablet stamped "Elev. 777 Columbus 1900" and "Prim. Trav. Sta. No. 2, 1906."	35	10	59.3	81	12	21.4
Ridge station, public-road crossing 1 mile south of	35	11	54.6	81	12	32.9
Ridge station, public-road crossing 1,000 feet north of	35	12	45.2	81	12	01.2
Ridge station, public-road crossing 1.25 miles north of	35	13	57.8	81	11	39.1
Catawba Creek, trestle over	35	14	47.6	81	11	09.5
Gastonia, crossing of Carolina and Northwestern and Southern Rwys. at	35	15	51.8	81	10	40.3
Gastonia, set in southwest corner of public square about 300 feet southwest of passenger station at, P. B. M. post stamped "Prim. Trav. Sta. No. 3, 1906"	35	15	49.6	81	11	01.2

KINGS MOUNTAIN QUADRANGLE (CLEVELAND AND GASTON COUNTIES, N. C.; CHEROKEE AND YORK COUNTIES, S. C.).

Geographic positions along Southern Railway between Gastonia and Kings Mountain, N.C.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Toray cotton mills, public-road crossing 500 feet north of	35	15	47.2	81	11	59.2
Arlington cotton mill, second-class road crossing 50 feet east of spur track	35	15	52.3	81	12	39.8
Milepost 405, second-class road crossing 200 feet west of	35	16	43.7	81	13	58.7
Public-road crossing	35	17	04.0	81	14	23.6
Bessemer City, 0.75 mile northeast of, second-class road crossing	35	16	56.9	81	16	18.1
Bessemer City station, 50 feet southeast of, crossing of main track	35	17	03.3	81	17	02.6
Bessemer City station, overhead road crossing 0.75 mile west of	35	16	58.0	81	17	42.6
Vantines station, public-road crossing 1,200 feet west of	35	16	52.9	81	18	22.8
Milepost 411, second-class road crossing 40 feet northeast of	35	16	17.1	81	19	07.3
A[illegible]la Mills, public-road crossing just east of station	35	15	06.1	81	19	58.0
Kings Mountain station, road crossing 300 feet north of	35	14	21.0	81	20	41.2
Kings Mountain, four corners at east edge of	35	14	26.7	81	20	11.4
Kings Mountain triangulation point, forks of road about 1 mile west of	35	13	08.2	81	20	03.7
Intersection of second-class roads east and north and public road southeast, 10 feet north to mail box at pine tree	35	12	52.0	81	19	42.2
Kings Mountain triangulation station, on highest point of Kings Mountain, 3 miles southeast of station and postoffice of same name and 31 miles west-southwest of Charlotte, N. C. Height of station, 1,700 feet. Station mark: A glass lamp shade filled with ashes, plugged at both ends, with a brick platform 5 feet square laid in cement, over it, with the diagonal of the square north, south, east, and west (true), a square hole 8 inches on a side being left at station center	35	12	27.72	81	18	45.52
Kings Mountain, set at east building line at corner where porch joins street crossing and about 250 feet north of passenger station, iron post stamped "Prim. Trav. Sta. No. 4, 1906"	35	14	20.3	81	20	42.3

Geographic positions along highways, North Carolina.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Kings Mountain station, 1.25 miles west of, forks, public roads northeast and southeast, 35 feet north to black gum, 60 feet east to telegraph pole	35	14	26.4	81	21	54.3
Second-class road to south at new dwelling, 30 feet southwest to oak tree, 25 feet west to pine stump	35	14	18.2	81	23	11.9
Second-class north-south crossroads, 30 feet northwest to J. W. Shart's mail box, No. 14, 25 feet northeast to small pine	35	14	35.1	81	24	10.1
Public roads northwest and west, fork of pine trees at, line turns west	35	14	58.4	81	24	40.2
Second-class road to northwest, 10 feet northeast to oak stump	35	14	49.8	81	25	45.2
Public roads, east and south forks of; 35 feet northwest to telegraph pole, 40 feet north to oak bush on bank	35	14	39.1	81	26	35.3
Buffalo Creek, 900 feet east of bridge over, forks of road south uphill, 40 feet south to oak tree, 30 feet north to telegraph pole	35	15	14.1	81	27	25.5
Four corners, second-class crossroads southwest and northeast, 40 feet east to double oak tree, 35 feet northwest to double oak tree	35	15	46.3	81	28	16.8
Shelby, 3 miles southeast of, public crossroads, four corners, 24 feet east to telegraph pole, 36 feet southwest to signpost	35	16	29.8	81	29	45.5
Four corners, public crossroads at blacksmith's shop, 50 feet southwest to H. M. Byer's mail box, 40 feet southeast to small apple tree	35	15	18.2	81	30	19.4
Four corners, public crossroads, 25 feet east to old peach-tree stump	35	14	46.3	81	30	33.8

Geographic positions along Southern Railway between Patterson Springs and Blacksburg.

Station.	Latitude.			Longitude.		
NORTH CAROLINA.	°	′	″	°	′	″
Patterson Springs station, 75 feet north of, public-road crossing of Southern Rwy	35	13	59.7	81	30	57.9
Patterson Springs station, 1.25 miles south of, public-road crossing	35	13	05.3	81	31	44.9
Public-road crossing	35	12	18.4	81	31	52.7
Earl station, 250 feet north of, public-road crossing	35	11	45.8	81	32	02.9
Earl station, 1 mile south of, second-class road crossing	35	10	55.6	81	32	04.4
SOUTH CAROLINA.						
North Carolina-South Carolina State line crossing	35	10	17.8	81	32	17.[illegible]
Second-class road crossing	35	09	29.7	81	32	43.5
Water mill, public-road crossing just south of	35	08	47.4	81	32	11.9
Blacksburg, public-road crossing north of (telegraph road), 37 feet northwest to nail in tie at road crossing	35	08	09.2	81	31	53.7
Blacksburg, southwest corner of Southern Rwy. park, 200 feet southwest of railroad station and 60 feet south of center of main track, iron post stamped "Prim. Trav. Sta. No. 12, 1906"	35	07	22.8	81	30	52.9
Blacksburg, main track of Southern Rwy., at west end of girder span over Ohio River and Charleston R. R	35	07	31.1	81	30	36.1
Blacksburg, 0.75 mile southeast of, public-road crossing	35	06	30.2	81	30	22.1
Blacksburg, 1 mile southeast of, public-road crossing Ohio River and Charleston R. R., spur line to Gaffney	35	06	04.5	81	30	52.5

Geographic positions along highways, South Carolina.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Blacksburg, 2 miles southeast of, public crossroads, forks of	35	05	22.9	81	30	25.0
Hopeville Church, forks of road 200 feet west of, 251 feet northeast to oak	35	04	43.1	81	30	03.6
Forks of public roads west and northwest, on Southwest slope of Jefferson Mountain, 30 feet north to small pine	35	04	10.3	81	29	46.2
Four corners at public crossroads, 60 feet south to oak tree, 50 feet west to oak, 40 feet northeast to mail box	35	03	27.6	81	29	00.3
Forks of public roads south and southeast, 0.50 mile north of bridge over Kings Creek, 25 feet south to bunch of plum bushes	35	02	49.2	81	28	41.5
Forks of second-class road to west, 10 feet west to post, 20 feet east to small pine tree	35	02	24.0	81	28	29.0
Wolf Creek, 0.25 mile northwest of, second-class road to east, 25 feet northeast to small pine tree, 800 feet southeast to house on top of hill	35	02	29.7	81	28	00.2
Wolf Creek, center of bridge over	35	02	27.8	81	27	44.1
Broad River schoolhouse, three corners at, 10 feet south to oak tree, 20 feet north to center main road	35	01	36.7	81	27	24.2
Forks of roads southwest and south, 30 feet southwest to pine	35	00	49.1	81	27	34.9
Four corners at second-class crossroads, 0.50 mile north of Mud Creek, 25 feet southeast to four mail boxes	35	00	21.5	81	27	35.4
Forks of roads northwest and northeast, 10 feet north to stake painted "632," 15 feet east to pine stump	34	59	50.0	81	27	29.8

SHELBY QUADRANGLE (CLEVELAND COUNTY, N. C.).

Geographic positions along highways.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Shelby, 3 miles east of, four corners, crossroads, 24 feet east to telephone pole, 36 feet southwest to signpost	35	16	29.8	81	29	48.5
Shelby, 3 miles east of, 50 feet northwest of intersection of crossroads, iron post stamped "Prim. Trav. Sta. No. 5, 1906"	35	16	30.1	81	29	48.9
Second-class forks of road to southwest, 30 feet southwest to small oak, 15 feet east to B. M. Habright's mail box	35	16	46.1	81	31	13.5
Shelby, intersection of Washington and Warren streets	35	17	26.9	81	32	20.5
Shelby, 100 feet southeast of southeast corner of Cleveland County court-house, south meridian stone, "Prim. Trav. Sta. No. 6, 1906"	35	17	27.9	81	32	22.0
Shelby, T road west of, center of grass plot, 25 feet east to oak, 2.25 miles to Zonar, 30 feet west to cedar	35	17	21.4	81	33	46.8
Broad River, center of iron bridge over	35	17	40.4	81	34	14.7
Forks of road, 0.12 mile west of bridge over Bushy Creek, roads west and southwest, 60 feet northeast to small bridge, 60 feet southwest to small stream	35	17	39.0	81	34	56.9
Bushy Creek, 1 mile west of, four corners, 40 feet southwest to corner of front-yard fence, 50 feet northeast to potato house	35	17	42.3	81	35	52.2
Three corners, second-class T road south, 30 feet southeast to new garden fence, 80 feet northwest to oak	35	17	51.2	81	36	57.3
Three corners, second-class T road south, 25 feet southwest to northeast corner of store, 25 feet north to telephone pole	35	17	32.2	81	38	14.2
Lattimore, 2.5 miles south of, 7 miles west of Shelby and 3 miles east of Mooresboro, in southeast corner of intersection of crossroads, iron post stamped "Prim. Trav. Sta. No. 7, 1906"	35	17	43.9	81	39	14.6
Second-class crossroads, 30 feet west to two small oaks, 5 feet south to oak stump	35	17	49.8	81	40	11.4
Forks at Sandy Run Creek, crossroads northeast and southeast, east end of bridge over creek	35	17	53.9	81	40	56.9
Mooresboro, east edge of, forks at top of hill, crossroads northwest and west, 50 feet northeast to corner of front-yard fence, 30 feet southwest to front gate of 2-story white dwelling	35	17	51.2	81	41	45.4
Mooresboro station, 600 feet north of, road crossing Southern Rwy., center of track	35	17	50.5	81	42	05.9
Crossroads at cotton gin, four corners 70 feet southwest to northeast corner of boiler house	35	17	36.2	81	43	20.9
Second-class forks of road to south, 30 feet north to telephone pole, 25 feet south to two mail boxes	35	17	10.8	81	44	03.4
Four corners, crossroads, 20 feet southwest to oak tree, 30 feet east to pine tree	35	16	46.4	81	44	52.6
Oak tree at forks, roads southwest to Henrietta and northwest to Caroline Mills	35	16	29.9	81	46	08.4
Henrietta, 0.5 mile east of, four corners, 44 feet southeast to primary-traverse station No. 8	35	15	56.8	81	46	56.3
Henrietta, 0.5 mile east of, in southeast corner of intersection of crossroads, at northwest corner of residence of Thos. Harris, iron post stamped "Prim. Trav. Sta. No. 8, 1906"	35	15	56.5	81	46	56.0
Road crossing, 1 mile east of Henrietta, center of track	35	15	22.1	81	46	36.6

GAFFNEY QUADRANGLE (CLEVELAND COUNTY, N. C.; CHEROKEE COUNTY, S. C.).

Geographic positions along highways.

Station.	Latitude.			Longitude.		
NORTH CAROLINA.						
	°	′	″	°	′	″
Cliffside, north edge of, 200 feet southwest of church and schoolhouse, roads north and east, 60 feet northwest to telephone pole	35	14	40.9	81	46	03.2
Forks of roads south and southeast, 10 feet north to signboard "Newferry ½ mile," 40 feet south to signboard	35	13	50.9	81	46	10.1
North landing of New or Snug's ferry across Broad River, 2 miles south of Cliffside	35	13	21.1	81	45	48.5
New Ferry, forks 0.75 mile south of, roads south and southeast, 50 feet north to oak, 10 feet west to pine stump, 30 feet east to Richard White's mail box	35	12	50.2	81	45	35.3
Luck Creek, 0.5 mile south of, forks of road, roads south and southeast, 20 feet southwest to telephone pole, 30 feet east to pine	35	12	14.8	81	45	14.7
Prospect Church, four corners 700 feet east of, 20 feet east to telephone pole, 10 feet southeast to pine	35	12	01.7	81	45	12.2
Small oak tree at second-class T road west	35	10	55.0	81	45	45.3
Oak tree at three corners, T road east	35	10	08.7	81	45	34.4

Geographic positions along highways—Continued.

Station.	Latitude.			Longitude.		
SOUTH CAROLINA.	°	′	″	°	′	″
Maud post-office, crossroads, 30 feet southeast to oak, 35 feet west to pine	35	08	45.8	81	44	47.1
Maud post-office, 1.4 miles southwest of, forks of roads east and southeast, 25 feet north to oak tree, 15 feet south to double oak	35	07	56.7	81	46	05.7
Forks of roads east and southeast, New Cut road to southeast, 30 feet southeast to oak, 10 feet north to small double oak	35	07	39.3	81	46	45.7
Large oak at forks, roads south and southwest	35	07	22.0	81	46	25.7
Maud post-office, 3.5 miles southwest .f, 0.75 mile west of Thickety Mountain, in northwest corner of intersection of crossroads, iron post stamped "Prim. Trav. Sta. No. 9, 1906"	35	06	59.2	81	47	05.3
Thickety Mountain, highest point on top of	35	06	47.9	81	46	06.8
Four corners north and southeast, second-class road southwest and northwest, 40 feet south to corner of log crib, 40 feet northwest to oak in corner of barnyard	35	06	34.8	81	47	05.5
Forks, 200 feet south of new schoolhouse, roads northwest and southwest, 40 feet west to two mail boxes, 10 feet south to pine	35	06	08.7	81	46	07.5
Forks of road to south, second-class road to southeast, 10 feet west to Lender's mail box No. 34	35	05	57.4	81	45	32.6
Thickety Creek, center of bridge over	35	05	06.2	81	45	27.8
Four corners, 15 feet north to small bridge, 60 feet southwest to well, 25 feet east to cherry tree	35	04	13.9	81	45	35.3
Four corners, 20 feet north to small double oak, 30 feet northwest to four mail boxes	35	03	29.5	81	45	07.0
Forks of second-class road to northeast, 100 feet north of red house, 10 feet east to oak, 15 feet northeast to oak	35	02	17.0	81	44	41.8
Thickety, 1 mile northwest of, center of triangle grass plot	35	01	16.4	81	44	05.5
Road crossing Southern Rwy. 0.25 mile west of Thickety station, center of track	35	00	58.3	81	43	29.6
Forks of second-class road to southeast, 20 feet northeast to small oak.	35	00	33.8	81	42	55.9
Little Thickety Creek, center of, at ford	35	00	04.5	81	42	30.2
Goucher post-office, forks of road 1 mile northwest of, 10 feet southwest to small pine, 30 feet east to small pine	34	59	14.4	81	42	32.1
Four corners 125 feet southeast of C. E. Smith's store (Goucher post-office)	34	58	52.8	81	41	46.5
Goucher post-office, southeast corner of store and post-office, iron post stamped "Prim. Trav. Sta. No. 10, 1906"	34	58	52.6	81	41	46.6
South end of covered bridge over Thickety Creek, 0.75 mile north of Goucher	34	59	25.4	81	41	27.4
Three corners, second-class T road to south, near top of hill and opposite two-room log dwelling	34	59	27.5	81	40	28.3
Second class fork to west, 50 feet northeast to pine	35	00	07.8	81	39	34.7
Gaffney, 5 miles south of, four corners at cotton gin, 1.5 miles northwest of church at crossroads, 5 feet south to small bridge	35	00	37.0	81	38	51.4
Corinth Church, 0.5 mile southeast of, forks of roads south and southeast, 30 feet east to oak and pine, 4 feet northeast to oak	35	00	23.7	81	38	00.4
Triangle grass plot at forks of roads northeast and southeast, 5 feet west to M. C. and C. A. Spencer's mail box, 10 feet east to clump of small ash trees	35	00	28.5	81	37	19.3
Forks 100 feet north of house on hill, second-class road to northeast, 50 feet north to corner of garden, 50 feet south to corner of garden	35	00	05.3	81	36	31.4
Four corners, crossroads, 900 feet west of brick house, 30 feet east to small oak, 20 feet south to small pine	34	59	38.3	81	35	42.8
Forks 0.5 mile northeast of Gilker Creek, roads northeast and southeast	34	59	34.7	81	35	02.2
Wilkinsville, 3.25 miles northwest of, T road southwest, 20 feet southwest to oak stump, 15 feet southeast to oak snag	34	59	56.7	81	34	00.3
Forks of second-class road north, 20 feet east to oak, 25 feet northwest to I. G. Patrick's mail box, No. 22	34	59	34.6	81	32	58.4
Wilkinsville, 0.75 mile northwest of, four corners, second-class crossroads, 50 feet west to cedar	34	58	39.4	81	32	26.[illegible]
Wilkinsville, at southeast corner of C. W. Whesonant's store, iron post stamped "Prim. Trav. Sta. No. 11, 1906"	34	58	18.4	81	31	54.7
Forks, 350 feet east of ford of creek, roads east and southeast to bunch of ash trees	34	58	34.8	81	30	43.1
Forks of roads southwest, 25 feet northeast to large oak, 30 feet southeast to double pine	34	59	17.0	81	29	57.9
West bank of landing of Broad River at Smith's ford	34	59	43.2	81	29	06.[illegible]
Large tree at forks of road 300 feet east of east bank of Broad River at Smith's ford	34	59	41.8	81	28	53.[illegible]
Smith's ford, 1 mile east of, at northeast corner of front-yard fence of residence of T. Smith, on top of hill, iron post stamped "Prim. Trav. Sta. No. 7, 1905"	34	59	03.4	81	28	08.9

OHIO.

PRIMARY TRAVERSE.

COSHOCTON, DEFIANCE, FAIRFIELD, FULTON, GUERNSEY, HENRY, LICKING, LUCAS, MORGAN, MUSKINGUM, NOBLE, PAULDING, PERRY, WILLIAMS, AND WOOD COUNTIES.

BRYAN, BUTLER, CALDWELL, CAMBRIDGE, CONESVILLE, CONTINENTAL, COSHOCTON, CUMBERLAND, DEFIANCE, DESHLER, EDON, FRAZEYSBURG, GRANVILLE, LOGAN, M'CLURE, MONTPELIER, NEWARK, NEW COMERSTOWN, NEW LEXINGTON, OTTAWA, PAULDING, PHILO, STRYKER, SUGARGROVE, SWANTON, THORNVILLE, THURSTON, WAUSEON, AND ZANESVILLE QUADRANGLES.

During the season of 1905, J. R. Ellis, assistant topographer, ran 658 miles of primary traverse to control the above-mentioned quadrangles. These quadrangles are situated in two general localities—one group being in the northwest corner of the State, the other near the central portion of the State, immediately east of Columbus.

The lines were tied to points previously located by primary traverse and also to triangulation stations Correy, Sago, and Widder.

BRYAN QUADRANGLE (DEFIANCE AND WILLIAMS COUNTIES).

Geographic positions along highways.

Station.	Latitude.			Longitude.		
	°		"	°	'	"
The Bend, railroad crossing 60 feet east of station	41	16	57.1	84	30	55.1
T. 4 N., R. 3 E., corner secs. 15, 16, 21, and 22, cross pikes	41	17	46.6	84	30	55.6
T. 4 N., R. 3 E., corner secs. 9, 10, 15, and 16, crossroads	41	18	38.8	84	30	56.0
T. 4 N., R. 3 E., corner secs. 3, 4, 9, and 10, crossroads	41	19	31.1	84	30	56.2

Geographic positions along Cincinnati Northern Railroad near east border of quadrangle.

Station.	Latitude.			Longitude.		
	°	'	"	°	'	"
Moats, railway crossing 0.5 mile north of	41	20	22.8	84	31	30.4
Moats, railway crossing 1.5 miles north of	41	21	15.3	84	31	31.1
Ney, 0.5 mile south of, in northwest corner of pasture owned by John Burt, at east-west crossing of Baltimore and Ohio Rwy.; nail in north face of walnut tree bears S. 6° W., distant 18 feet; east rail of track at north-south crossing bears N. 74° W, distant 51 feet; iron post stamped "Prim. Trav. Sta. No. 14, 1905"	41	22	33.7	84	31	31.5
Ney, railway crossing east and west 1 mile north of	41	23	52.2	84	31	33.0
Ney, railway crossing east and west 2 miles north of	41	24	44.2	84	31	33.6
Defiance-Williams county line, east-west road crossing of Cincinnati Northern R. R.	41	25	36.8	84	31	34.2
Defiance-Williams county line, east-west road crossing 1 mile north of.	41	26	29.3	84	31	34.9
Bryan, east-west crossing 1.25 miles south of	41	27	21.9	84	31	37.9
Bryan, crossing 400 feet south of tank on Cincinnati Northern R. R.	41	28	06.8	84	32	31.1

Geographic positions near south border of quadrangle.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
T. 6 N., R. 3 E., northeast corner sec. 11, in northwest corner of field owned by S. J. Bowman, southwest corner of schoolhouse bears N. 26° 30′ E., distant 161 feet; iron post stamped "Prim. Trav. Sta. No. 15, 1905"	41	29	58.7	84	28	[illegible]
T. 3 N., R. 2 E., northeast corner of sec. 3, in northeast corner of field of Henry Martin, iron post stamped "Prim. Trav. Sta. No. 7, 1905"	41	15	09.0	84	36	[illegible]
T. 4 N., R. 2 E., south corner secs. 33 and 34, T road north	41	15	08.9	84	37	[illegible]
T. 4 N., R. 2 E., south corner secs. 32 and 33, T road north	41	15	08.6	84	38	[illegible]
Tps. 3 and 4 N., Rs. 1 and 2 E., corner secs. 1, 6, 31, and 36, crossroads	41	15	07.9	84	41	19.9

Geographic positions near west border of quadrangle.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
T. 3 N., R. 1 E., north corner secs. 1 and 2, T road south	41	15	07.8	84	42	[illegible]
T. 4 N., R. 1 E., south corner secs. 34 and 35	41	15	07.8	84	43	[illegible]
Edgerton, 3 miles north of, in southwest corner of yard to schoolhouse No. 22, St. Joseph township, southwest corner of schoolhouse bears N. 62° 40 E. distant 61 feet; iron post stamped "Prim. Trav. Sta. No. 21, 1905"	41	29	38.3	84	44	[illegible]
T. 6 N., R. 1 E., corner secs. 9, 10, 15, and 16, T road west	41	29	01.7	84	44	[illegible]
T. 6 N., R. 1 E., secs. 15, 16, 21, and 22, T road east	41	28	09.5	84	44	[illegible]
T. 5 N., R. 1 E., corner secs. 3 and 4, Defiance-Williams county line	41	25	33.1	84	44	54.7
T. 5 N., R. 1 E., corner secs. 3, 4, 9, and 10, crossroads	41	24	40.6	84	44	[illegible]
T. 5 N., R. 1 E., corner secs. 9, 10, 15, and 16, crossroads	41	23	48.7	84	44	[illegible]
T. 5 N., R. 1 E., corner secs. 15, 16, 21, and 22, crossroads	41	22	56.3	84	44	[illegible]
T. 5 N., R. 1 E., corner secs. 21, 22, 27, and 28, crossroads	41	22	04.3	84	44	[illegible]
T. 5 N., R. 1 E., 4 miles north of Hicksville, northwest corner sec. 34, northwest corner of yard to school yard No. 9, limestone post 38 by 6 by 4 inches, aluminum tablet stamped "Prim. Trav. Sta. No. 22"	41	21	11.8	84	44	[illegible]
Tps. 4 and 5 N., R. 1 E., corner secs. 3, 4, 33, and 34, crossroads	41	20	20.0	84	44	[illegible]
T. 4 N., R. 1 E., corner secs. 3, 4, 9, and 10, crossroads	41	19	28.6	84	44	[illegible]
Hicksville, Bryan-Hicksville pike at road north, 1 mile northeast of	41	18	10.7	84	44	[illegible]
Hicksville, High street at Antwerp pike south, in southwest part of	41	17	23.3	84	45	[illegible]
Hicksville, crossroads 2 miles south of, 25 feet northwest to north end of culvert, 45 feet southeast to cross cut on telephone pole	41	15	59.8	84	45	40.1
Antwerp, 5 miles north of, in northwest corner of field of Everett Longsworth, at crossroads, 1.5 feet southeast of large corner fence post, iron post stamped "Prim. Trav. Sta. No. 1, 1905"	41	15	07.6	84	45	[illegible]

BUTLER QUADRANGLE (DEFIANCE AND WILLIAMS COUNTIES).

Geographic positions along highways near Ohio-Indiana State line.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
T. 4 N., R. 1 E., south corner secs. 31 and 32, T road north	41	15	07.9	84	47	[illegible]
T. 5 N., R. 1 E., corner secs. 29, 30, 31, and 32, crossroads	41	21	11.8	84	47	[illegible]
T. 5 N., R. 1 E., corner secs. 19, 20, 29, and 30, crossroads	41	22	04.0	84	47	[illegible]
T. 5 N., R. 1 E., corner secs. 17, 18, 19, and 20, crossroads	41	22	56.1	84	47	[illegible]
Ohio-Indiana State line, center of road	41	23	10.8	84	48	12.6
Edgerton, 3 miles southwest of, T road west near schoolhouse, 40 feet southeast to walnut tree on fence line 30 feet northwest to cross on corner fence post	41	24	44.6	84	47	[illegible]
Tps. 5 and 6 N., R. 1 E., corner secs. 1, 6, 31, and 36, T lane east	41	25	32.8	84	48	[illegible]
Ohio-Indiana State line, post on, near Lake Shore and Michigan Southern Rwy	41	26	17.8	84	48	[illegible]
Astronomic value	41	26	13.7	84	48	[illegible]
Edgerton, road crossing, south rail of north track Lake Shore and Michigan Southern Rwy., 1.5 miles southwest of	41	26	33.2	84	46	[illegible]
Edgerton, T road south 1.5 miles west and 1 mile north of, 25 feet southeast to cross on corner fence post, 27 feet southwest to cross on corner fence post	41	27	43.6	84	46	[illegible]
Ohio-Indiana State line, stone at turn of road and 600 feet south of T road west	41	27	43.2	84	48	[illegible]
T. 6 N., R. 1 E., secs. 7 and 18, T road east at west corner of	41	29	01.4	84	48	[illegible]

CALDWELL QUADRANGLE (NOBLE COUNTY).

Magnetic declination, north border, 2° 21′ west.

Geographic positions along highways.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Correy triangulation station, in Olive Township, on summit of hill locally known as Correy Knob, on land of John Hughes, covered with a peach orchard. Station mark: A stone post 40 by 6 by 6 inches set 36 inches in the ground, in center of top of which is cemented a bronze triangulation tablet	39	43	27.31	81	32	47.22
Sharon, T. 6 S., R. 9 W., corner secs. 5, 6, 7, and 8, crossroads	39	44	10.1	81	33	53.9
Sharon, 1.5 miles west of, Nicolas (J.) residence, just south of, T road southwest, 9 feet west to J. Wallace's mail box	39	44	22.9	81	35	29.9
Olive Green, T road south, 11 feet due south to center of small bridge.	39	44	38.7	81	36	53.0

CAMBRIDGE QUADRANGLE (COSHOCTON AND MUSKINGUM COUNTIES).

Magnetic declination, north border, 1° 57′ west; west border, 2° 09′ west; 2° 10′ west.

Geographic positions along highways.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
West Lafayette, 2.5 miles south of, McClain's schoolhouse, forks of road at, 24 feet southeast to guidepost, 22 feet northwest to cross on corner fence post	40	14	37.3	81	44	30.4
West Lafayette, 3 miles south of, at guidepost "Lafayette 3 mi. Plainfield 4 mi.," T road north, 37 feet northwest to guidepost, 39 feet northeast to cross on telegraph pole	40	13	53.0	81	44	41.2
Bridge over Bacon Run, 0.18 mile north of, T road west, 30 feet northeast to front-yard gate, 34 feet southeast to mail box	40	13	12.8	81	43	40.6
Plainfield, 0.5 mile west of, crossroads, 30 feet northeast to cross on corner fence post, 24 feet southeast to sandstone bowlder	40	12	13.1	81	43	30.1
Flowing well, T road northwest at, 14 feet east to flowing well, 21 feet west to cross on corner fence post	40	11	22.2	81	44	10.0

CONESVILLE QUADRANGLE (COSHOCTON AND MUSKINGUM COUNTIES).

Magnetic declination, north border, 0° 34′ east; east border, 2° 09′ west, 2° 10′ west; south border, 1° 52′ west.

Geographic positions along Wheeling and Lake Erie Railroad near Ellis.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Milepost 5, north-south road crossing	40	00	25.6	81	58	59.9
Lane's poultry farm, private road crossing at spur	40	01	46.9	81	59	36.7
Ellis station, center of track opposite	40	02	46.4	81	58	58.4
Trestle 135A, north-south road crossing under	40	03	33.1	81	58	49.7

Geographic positions along highways.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
McCleary (Seth) residence, 0.25 mile east of, T road north, 16 feet north to mail box, 24 feet northeast to cross on corner fence post	40	10	23.9	81	45	37.9
Wills Creek, W. Roderick's bridge over, north end of	40	10	00.7	81	46	20.0
T. 4 N., R. 5 W., quarter corner between secs. 23 and 24, stone	40	09	41.5	81	46	22.2
Otsego, 2 miles north of, crossroads, 9 feet southeast to J. E. Simmons's mail box, 18 feet east to cross on fence post	40	08	55.5	81	46	07.7
Otsego, in southwest corner of public school grounds, iron post stamped "Prim. Trav. Sta. No. 59, 1905"	40	07	04.3	81	45	58.0
Otsego, 2.5 miles south of, 0.25 mile northeast of covered bridge, crossroads, 27 feet northwest to cross on telegraph pole, 22 feet southwest to cross on gatepost	40	05	06.4	81	46	01.2
D. W. Ross's mail box, T road west	40	03	29.8	81	46	26.3
Corner of sections (no numbers)	40	02	10.8	81	46	11.0
Sago triangulation station, on a bald hill 4 miles southwest of Sago, on land of J. W. Carnes. Station mark: A limestone post 40 by 7 by 7 inches set 39 inches in the ground, in center of top of which is countersunk and cemented a bronze triangulation tablet (Ohio)	40	00	42.40	81	46	55.70

CONTINENTAL QUADRANGLE (PAULDING COUNTY).

Geographic positions along highways near west border of quadrangle.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
T. 1 N., R. 3 E., at crossroads 1 mile north and 1 mile west of Grover Hill, in southeast corner of field owned by F. M. Saul, iron post stamped "Prim Trav. Sta. No. 4, 1905"	41	02	02.5	84	29	44.8
T. 1 N., R. 3 E. corner secs. 10, 11, 14, and 15, crossroads	41	02	54.6	84	29	44.5
T. 1 N., R. 3 E., corner secs. 2, 3, 10, and 11, crossroads	41	03	46.9	84	29	44.8
T. 1 N., R. 3 E., north corner secs. 2 and 3, T road south	41	04	39.6	84	29	44.7
T. 2 N., R. 3 E., corner secs. 26, 27, 33, and 34, crossroads	41	05	31.9	84	29	44.4
T. 2 N., R. 3 E., corner secs. 22, 23, 26, and 27, crossroads	41	06	24.6	84	29	44.6
T. 2. N., R. 3 E., southeast corner sec. 15, in southeast corner of field of Geo. Older, northeast corner of C. Stutsman's house bears S. 37° E., distant 188 feet; iron post stamped "Prim. Trav. Sta. No. 5, 1905"	41	07	17.2	84	29	45.0
T. 2 N., R. 3 E., corner secs. 10, 11, 14, and 15, crossroads	41	08	09.4	84	29	44.6
T. 2 N. R. 3 E., corner secs. 2, 3, 10, and 11, crossroads	41	09	01.8	84	29	44.7
T. 2 N., R. 3 E., corner secs. 3, 4, 9, and 10, crossroads	41	09	01.3	84	30	54.6
T. 2 N., R. 3 E., north corner secs. 3 and 4, jog in road	41	09	54.6	84	30	54.9
T. 3 N., R. 3 E., corner secs. 27, 28, 33, and 34, crossroads	41	10	47.1	84	30	52.3
T. 3 N., R. 3 E., corner secs. 26, 27, 34, and 35, crossroads	41	10	47.6	84	29	42.4
T. 3 N., R. 3 E., corner secs. 22, 23, 26, and 27, center of bridge over canal	41	11	39.4	84	29	42.6
Sixmile Creek, center of bridge over	41	12	27.7	84	29	43.1
T. 3 N., R. 3 E., east corner secs. 10 and 15, T road west	41	13	24.6	84	29	43.7
T. 3 N., R. 3 E., corner secs. 2, 3, 10, and 11, crossroads	41	14	17.0	84	29	44.7
T. 3 N., R. 3 E., 30 feet west and 30 feet south of quarter corner between secs. 2 and 3, in northeast corner of field owned by Saul Meyer & Co., south rail of Wabash R. R. at section line crossing bears N. 19° E., distant 70 feet; iron post stamped "Prim. Trav. Sta. No. 6, 1905"	41	14	42.9	84	29	45.5

COSHOCTON QUADRANGLE (COSHOCTON COUNTY).

Magnetic declination, south border, 0° 34′ east.

Geographic positions along highways.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Guidepost "Coshocton 7 miles," road south, 60 feet southeast to guidepost, 24 feet northeast to cross on corner of rail fence	40	15	10.8	81	59	07.4
Center of Sixmile bridge at crossroads	40	15	03.7	81	57	40.7
Pleasant Hill Church, 1 mile east of, road to southwest, 42 feet southwest to A. C. Warren's mail box, 28 feet northwest to peach tree	40	15	01.2	81	56	12.2
Coshocton, 3.5 miles west of, just northwest of Joseph Kirker's residence, T road north, 21 feet southeast to cross on fence post, 21 feet west to cross on rail fence	40	15	47.7	81	55	07.8
Junction of Mount Vernon and Tyrone roads, 300 feet south of, center of iron bridge over creek	40	16	18.6	81	53	31.2
Roscoe, center of bridge over Ohio Canal	40	16	45.2	81	52	33.0
Coshocton, in southeast corner of Coshoction County court-house, aluminum tablet stamped "Prim. Trav. Sta. No. 57, 1905"	40	16	28.0	81	51	57.4

Geographic positions along Pennsylvania Railroad.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Milepost 71, 0.25 mile west of, road crossing, siding on south of main track	40	17	17.2	81	50	08.3
Milepost 72, just west of, private-road crossing, north track of main line	40	17	03.7	81	48	52.3
Morgan Run station, crossing of Pennsylvania and Wheeling and Lake Erie R. Rs	40	16	52.5	81	47	44.8
West Lafayette, 1 mile west of, overhead road crossing, south track	40	16	42.7	81	46	07.4

CUMBERLAND QUADRANGLE (MORGAN COUNTY).

Magnetic declination, south border, 2° 21′ west; west border, 1° 38′ west.

Geographic positions along highways.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Morgan County, at northeast corner of, stone corner on west side of road opposite cemetery and about 2 feet from corner of rail fence	39	45	09.8	81	38	24.5
Renrock, crossroads, 90 feet east to center of covered bridge, 27 feet south to center of culvert	39	45	28.8	81	40	20.4
Dickerson's mill, just east of, T road north, 24 feet northwest to cross on gatepost, 19 feet northeast to corner of rail fence	39	45	49.6	81	41	28.2
Oak Grove cemetery, on east side of, at rail fence, stone, Muskingum-Margrove county line	39	45	22.5	81	42	55.6
Knight, on Knight-Young Hickory road, 1 mile northwest of, J. H. Dingley's mail box	39	46	13.2	81	44	03.0
Young Hickory, T road east, 22 feet north to public mail box, 18 feet southeast to arrow on fence	39	46	46.0	81	44	57.9

DEFIANCE QUADRANGLE (DEFIANCE COUNTY).

Geographic positions along Wabash and Baltimore and Ohio Railroads near south border of quadrangle.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Ashwood, 1 mile west of station, road crossing north and south (section line)	41	15	02.6	84	28	34.5
Ashwood, road crossing at station	41	15	21.0	84	27	25.1
Ashwood, 1 mile east of, road crossing north and south (section line)	41	15	39.2	84	26	16.5
Defiance Junction. crossing of Wabash and Baltimore and Ohio R. Rs.	41	16	39.0	84	22	43.4
Defiance, in water table at southwest corner of Defiance County jail aluminum tablet stamped "Prim. Trav. Sta. No. 8, 1905"	41	17	11.3	84	21	38.9
Defiance, in southeast part of, Ottawa avenue, crossing of Baltimore and Ohio Southwestern R. R	41	16	46.8	84	21	03.4
Midway, 1,300 feet east of telegraph office, road crossing north and south	41	16	45.5	84	18	49.7
Midway, overhead crossing 1.25 miles east of	41	16	44.8	84	17	41.0
Milepost 82, north-south section line, road crossing 150 feet west of	41	16	29.2	84	15	57.1
T. 3 N., R. 3 E., secs. 2 and 3, T road south at north corner of	41	15	10.7	84	29	45.7
T road east	41	16	03.1	84	29	45.0
The Bend, north-south road crossing Baltimore and Ohio R. R. 1 mile east of	41	16	58.2	84	29	33.8

DESHLER QUADRANGLE (HENRY AND WOOD COUNTIES).

Geographic positions along highways on north border of quadrangle.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
T. 3 N., R. 8 E., northwest corner of sec. 7, in northwest corner of field, iron post stamped "Prim. Trav. Sta. No. 11, 1905"	41	14	21.9	83	59	50.9
T. 3 N., R. 8 E., corner secs. 5, 6, 7, and 8, crossroads, 48 feet north to center of bridge over ditch	41	14	22.7	83	58	41.8
T. 3 N., R. 8 E., secs. 4, 5, 8, and 9, crossroads	41	14	23.0	83	57	32.7
T. 3 N., R. 8 E., west corner secs. 3 and 10, T road east at schoolhouse, stone	41	14	23.6	83	56	23.3
T. 3 N., R. 8 E., corner secs. 2, 3, 10, and 11, crossroads at, 25 feet west to center of bridge	41	14	24.4	83	55	13.6
T. 3 N., R. 8 E., corner secs. 1, 2, 11, and 12, 28 feet northwest to John Sher's mail box, 30 feet southwest to end of iron bridge	41	14	25.1	83	54	04.4
T. 3 N., R. 9 E., west corner secs. 6 and 7, T road east, 15 feet northwest to small coffee-bean tree, Henry-Wood county line, 27 feet northeast to cross on telephone pole	41	14	25.6	83	52	53.9
T. 3 N., R. 9 E., northwest corner sec. 8, in field of Mrs. Rush, southwest corner of schoolhouse bears N. 15° 30′ E., distant 80.8 feet; cross cut on abutment of bridge bears N. 66° 20′ W., distant 16.8 feet; iron post stamped "Prim. Trav. Sta. No. 12, 1905"	41	14	26.1	83	51	43.5
T. 3 N., R. 9 E., corner secs. 4, 5, 8, and 9, 15 feet south to center of bridge over ditch, 12 feet north to crossroads	41	14	26.4	83	50	33.0
T. 3 N., R. 9 E., corner secs. 3, 4, 9, and 10, T road west at stone to (church and schoolhouse), 50 feet south to center of bridge over ditch	41	14	26.2	83	49	24.4
T. 3 N., R. 9 E., corner secs. 2, 3, 10, and 11, crossroads at stone to	41	14	25.8	83	48	14.6
T. 3 N., R. 9 E., east corner to secs. 2 and 11, crossroads at schoolhouse No. 1, stone	41	14	24.9	83	47	07.2
T. 3 N., Rs. 9 and 10 E., corner secs. 1, 6, 7, and 12, crossroads, 21 feet south to center of bridge, 21 feet southeast to Mrs. F. A. Lovell's mail box	41	14	26.9	83	45	57.4
T. 3 N., R. 10 E., northeast corner sec. 7, at crossroads at schoolhouse No. 2, cross cut in southwest corner of large stone culvert bears N. 11° E., distant 17.6 feet; southwest corner of schoolhouse bears N. 48° E., distant 126 feet; iron post stamped "Prim. Trav. Sta. No. 13, 1905"	41	14	26.1	83	44	46.5

EDON QUADRANGLE (WILLIAMS COUNTY).

Geographic positions along highways near Ohio-Indiana State line.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Ts. 6 and 7 N., R 1 E., west corner secs. 6 and 31, T road east	41	30	45.6	84	48	14.6
T. 7 N., R. 1 E., stone at corner secs. 30 and 31	41	31	38.0	84	48	15.1
T. 7 N., R. 1 E., west corner secs. 19 and 30, T road east	41	32	29.9	84	48	15.7
Edon, crossing of Wabash R. R. and Ohio-Indiana State line 2 miles west of	41	32	53.9	84	48	16.0
T. 7 N., R. 1 E., secs. 7 and 18, crossroads at west corner	41	34	13.9	84	48	17.3
T. 7 N., R. 1 E., west corner secs. 6 and 7, T road east	41	35	06.2	84	48	18.0
T. 8 N., R. 1 E., secs. 30 and 31, west corner, T road south	41	36	46.6	84	48	19.2
Columbia, crossroads	41	37	58.0	84	47	18.6
Columbia, road west 1.5 miles north of	41	39	10.8	84	47	36.3
Store, T road east just south of, 0.33 mile north of schoolhouse, 33 feet southeast to mail box, 44 feet northeast to apple tree	41	40	15.6	84	47	44.2
Ohio-Indiana State line, T road east, 1.25 miles south of northwest corner of Ohio	41	40	41.2	84	48	20.4
T road east	41	41	34.1	84	48	20.3
Ohio-Indiana-Michigan, corner of	41	41	45.5	84	48	20.2
T. 9 S., R. 4 W., corner secs. 8, 9, 16, and 17, T road north	41	41	34.7	84	47	10.0
T. 9 S., R. 4 W., corner secs. 9, 10, 15, and 16, T road north	41	41	35.6	84	46	00.3

FRAZEYSBURG QUADRANGLE (COSHOCTON, LICKING, AND MUSKINGUM COUNTIES).

Magnetic declination, west border, 3° 08′ west; north border, 0° 46′ west.

Geographic positions along highways.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Fallsburg, road west at hotel, 42 feet northwest to cross on telegraph pole, 58 feet southeast to stone step to store	40	12	16.6	82	14	18.0
Secs. 12 and 13, quarter corner between	40	12	47.2	82	13	58.9
Wakaton Creek, just east of Eli Frey's residence, east end of covered bridge over	40	13	15.1	82	13	16.8
Trampton, at schoolhouse, corner stone to secs. 1, 2, 9, and 10	40	13	37.8	82	12	11.9
Trampton, 1 mile east of, at Licking-Coshocton county line, T road south, forked post	40	13	40.6	82	11	01.7
Crossroads, guidepost at ("Bladensburg 8 mi.")	40	13	47.0	82	09	54.8
French Melick's residence, road north at, cross on telegraph pole	40	14	13.5	82	09	21.8
West Carlisle, 1.3 miles west of, road south, 15 feet to cross on fence post, 33 feet west to cross on telegraph pole	40	14	10.6	82	08	26.3
West Carlisle, in southwest corner of lot of H. M. Robinson; northwest corner of Presbyterian Church bears S. 1° 30′ E., distant 123 feet; nail in east face of locust tree bears N. 83° W., distant 46.2 feet; iron post stamped "Prim. Trav. Sta. No. 55, 1905"	40	13	43.7	82	07	00.0
Cooperdale, 1.66 miles west of, forks of road, 36 feet southwest to cross on fence post, 35 feet southeast to cross on corner of rail fence	40	13	52.4	82	05	50.6

Geographic positions along Cleveland, Akron and Columbus Railway, Cooperdale to Tunnel Hill.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Cooperdale, 0.33 mile north of, road crossing	40	13	22.6	82	04	05.3
Tunnel Hill, 1.75 miles south of, east-west road crossing	40	14	00.2	82	03	48.4
Tunnel Hill, 0.75 mile south of, northwest-southeast road crossing	40	14	47.0	82	03	13.9
Tunnel Hill, road crossing	40	15	17.4	82	02	56.3

Geographic positions along highways.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Tunnel Hill, 1.5 miles east of, T road north, 27 feet due south to cross on fence post	40	15	29.1	82	01	30.1
Tunnel Hill, 2 miles east of, near northwest corner of field of Wm. L. Wright; northeast corner of Wright's house bears S. 14° W., distant 87 feet; iron post stamped "Prim. Trav. Sta. No. 56, 1905"	40	15	18.9	82	00	32.8

Geographic positions along Baltimore and Ohio Railroad, Pleasant Valley to milepost 85.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Pleasant Valley, 1.5 miles southeast of, opposite milepost 86, center of track	40	00	09.7	82	06	54.4
Milepost 85, 275 feet east of, private road crossing	40	00	02.6	82	05	48.4

Geographic positions along highways.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Reform, 1.5 miles south of, T road east at H. L. Smith's residence, 36 feet southeast to cross on gatepost, 45 feet southwest to H. L. Smith's mail box	40	06	47.1	82	14	49.5
Hanover, 1 mile northeast of, five corners, 24 feet southeast to cross on corner fence post, 32 feet east to cross on picket at corner of fence	40	05	34.5	82	14	53.7

Geographic positions along Wheeling and Lake Erie and Cincinnati and Muskingum Valley railroads near Dresden.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Wheeling and Lake Erie R. R. milepost 11, center of track opposite	40	04	40.8	82	00	01.1
Dresden, 2 miles south of, milepost 4, just north of, east-west road crossing of Cincinnati and Muskingum Valley R. R	40	05	41.5	82	01	02.0
Milepost 3, 500 feet north of, east-west road crossing	40	06	33.5	82	00	42.5
Dresden, near northwest corner of public school grounds; northwest corner of schoolhouse bears N. 80° E., distant 137.3 feet; nail in root of maple tree bears S. 30° 30′ E., distant 13 feet; iron post stamped "Prim. Trav. Sta. No. 54, 1905"	40	07	17.8	82	00	49.5
Canal, road crossing under railroad bridge	40	07	57.6	82	01	02.4

Geographic positions along Cleveland, Akron and Columbus Railway, Trinway to Wakatomika.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Trinway station, just west of, crossing of Cleveland, Akron and Columbus and Pennsylvania R. Rs., main line, north track	40	08	36.3	82	00	54.4
Trinway, 2 miles north of, northwest-southeast road crossing, at covered bridge	40	10	16.3	82	01	46.8
Wakatomika, 0.75 mile south of, east-west road crossing	40	11	19.2	82	02	19.7
Wakatomika, 0.5 mile north of, road crossing	40	12	06.2	82	03	04.6
East-west road crossing	40	12	45.1	82	03	36.5

GRANVILLE QUADRANGLE (LICKING COUNTY).

Magnetic declination, east border, 0° 44′ west; north border, 0° 36′ west.

Geographic positions along highways, Croton to Homer.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Croton, 2.5 miles west and 0.5 mile south of, at crossroads at Wm. Farel's residence, in southeast corner of James Wilson's farm; nail in east face of cherry tree bears S. 89° W., distant 20 feet; iron post stamped "Prim. Trav. Sta. No. 40, 1905"	40	13	57.1	82	44	15.0
Croton, 1.25 miles west of, T road east, 36 feet southeast to cross on fence post, 27 feet northeast to Green's mail box	40	14	21.5	82	42	49.5
Croton, Delanon street crossing of railroad	40	14	20.7	82	41	20.1
Croton, 1 mile east of, T road north, 13 feet due south to cross board at west of wire fence	40	14	27.9	82	39	52.4
Bennington Township House, 1.66 miles west of, crossroads 300 feet south of schoolhouse, 21 feet northeast to B. E. Nash's mail box, 36 feet southeast to cross on corner fence post	40	14	22.5	82	38	26.4
Lock, 2 miles south of, Bennington Township House, at northwest corner of; nail in west oak bears S. 60° 45′ W., distant 19.8 feet; northwest corner foundation of house bears S. 80° 30′ E., distant 3.5 feet; iron post stamped "Prim. Trav. Sta. No. 39, 1905"	40	14	22.8	82	36	22.1
Bennington Township House, 1 mile east of, covered bridge over Otter Creek North, center of	40	14	40.5	82	35	14.3
Crossroads, 1,500 feet east of, Otter Creek East, center of iron bridge over	40	14	48.8	82	34	16.3
Homer, 1.66 miles west of, T road south, 42 feet southeast to cross on corner fence post, 40 feet southwest to hickory tree	40	15	25.5	82	33	17.2
Otter Creek East, center of covered bridge over	40	15	11.0	82	32	20.4
Homer, in northwest part of public school grounds; northwest corner of schoolhouse foundation bears S. 3° 45′ W., distant 78 feet; iron pump bears S. 70° W., distant 11.3 feet; iron post stamped "Prim. Trav. Sta. No. 38, 1905"	40	15	09.60	82	31	20.62

Geographic positions along Baltimore and Ohio Railroad, Summit to Union.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Summit station, 1 mile north of, in northwest corner of small lot owned by W. S. Griffith, lot situated just south of east-west section line, on east side of north-south road, iron post stamped "Prim. Trav. Sta. No. 34, 1905"	40	00	44.6	82	45	03.4
Milepost 24, private-road crossing, south track	40	00	08.3	82	33	26.6
Union station, 1.5 miles west of, east-west road crossing	40	00	34.9	82	32	26.1
Union station, 0.75 mile west of, crossroads, in southeast corner of Ira Showman's field; crosscut on stone abutment to bridge bears S. 9° 15′ E., distant 47.6 feet; iron post stamped "Prim. Trav. Sta. No. 36, 1905"	40	01	15.6	82	31	29.2
Union station, 0.5 mile east of, north-south gravel-road crossing	40	01	22.8	82	30	22.5

Geographic positions along highways, Granville to Union schoolhouse.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Granville, 1 mile south of, T road to west at schoolhouse, 19 feet northeast to cross on corner of fence, 7 feet south to end of culvert	40	02	53.3	82	31	25.2
Granville station, north-usoth street crossing, Toledo and Ohio Central Rwy	40	03	51.7	82	31	14.8
Granville station, 0.75 mile north of, T road west, 35 feet northwest to north end of culvert, 46 feet south to cross on telegraph pole	40	04	39.1	82	31	18.2
Schoolhouse No. 8, 1891, 0.5 mile north of, T road east, 30 feet southeast to corner of garden fence, 28 feet northeast to cross on telegraph pole	40	06	34.7	82	31	08.0
Brushy Creek, south end of iron bridge over	40	07	24.5	82	31	04.5
Fredonia, schoolhouse yard, in west part of, northwest corner of; foundation of schoolhouse bears S. 72° 30′ E., distant 122.6 feet; southeast foundation to Willard's store bears N. 46° 30′ W., distant 94.5 feet; iron post stamped "Prim. Trav. Sta. No. 37, 1905"	40	09	08.6	82	31	12.5
Highwater, crossroads, 63 feet south to northwest corner of store porch, 31 feet southwest to guidepost	40	10	34.4	82	31	10.7
Highwater, 1 mile north of, crossroads, 27 feet north to cross on corner of board fence, 60 feet north to J. F. Riley's mail box	40	11	22.3	82	31	05.2
Union schoolhouse, 0.5 mile south of, T road west, 16 feet due west to W. F. Wagoner's mail box	40	12	42.3	82	31	10.8
Union schoolhouse, 0.5 mile north of, crossroads, post	40	13	37.4	82	31	13.6

LOGAN QUADRANGLE (PERRY COUNTY).

Geographic positions along Cincinnati and Muskingum Valley Railroad near Junction City.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Milepost 42, 0.33 mile east of, road crossing	39	43	23.5	82	16	43.8
Junction City, near Stalzenbach & Harris's store, on north line between Cincinnati and Muskingum Valley Railroad and property of Junction City; southwest corner of store bears N. 26° 50′ W., distant 78.9 feet; north rail of track at road crossing bears S. 43° 45′ W., distant 53 feet; iron post stamped "Prim. Trav. Sta. No. 66, 1905"	39	43	13.4	82	17	57.0
Milepost 13, road crossing	39	43	24.6	82	20	00.6
McElroys, 1 mile south of, road crossing at spur	39	44	00.8	82	20	19.3
McElroys station, road crossing	39	44	57.3	82	19	53.2

M'CLURE QUADRANGLE (HENRY AND WOOD COUNTIES).

Geographic positions along highways near north border of quadrangle.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Whitehouse, 1.5 miles south of, crossroads and schoolhouse, 4 miles east of Neapolis, 44 feet northeast to school pump, 33 feet northwest to guidepost	41	29	43.1	83	48	2[illegible].6
Neapolis, 2.25 miles east of, crossroads, 32 feet southwest to Geo. Rapp's mail box, 23 feet northwest to northeast corner stone of culvert	41	29	42.6	83	49	36.0
Crossroads at schoolhouse, 28 feet northwest to cross on corner fence post, 39 feet southwest to S. Jewell's mail box	41	29	42.0	83	50	44.6
Neapolis, road crossing	41	29	32.9	83	52	23.9
T. 6 N., R. 8 E., sec. 12, southeast corner of, in southeast corner of field of Mary A. Long, iron post stamped "Prim. Trav. Sta. No. 30, 1905".	41	29	14.5	83	52	58.4
T. 6 N., R. 8 E., corner secs. 11, 12, 13, and 14, stone at crossroads	41	29	13.1	83	54	08.6
T. 6 N., R. 8 E., corner secs. 10, 11, 14, and 15, crossroads, 29 feet northwest to H. Leneman's mail box, 36 feet southwest to board on small tree	41	29	13.1	83	55	18.[illegible]
T. 6 N., R. 8 E., corner secs. 9, 10, 15, and 16, stone at crossroads	41	29	12.9	83	56	27.8
T road north, T. 6 N., R. 8 E., corner secs. 8, 9, 16, and 17, 22 feet southeast to F. C. March's mail box, 24 feet south to cross on fence post	41	29	12.5	83	57	37.5
T. 6 N., R. 8 E., corner secs. 7, 8, 17, and 18, crossroads, 36 feet northwest to mail box, 31 feet southwest to cross on telephone pole	41	29	12.1	83	58	47.8

MONTPELIER QUADRANGLE (WILLIAMS COUNTY).

Geographic positions along highways near Ohio-Michigan State line.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
T. 9 S., R. 2 W., corner secs. 10, 11, 14, and 15, T road north	41	41	40.6	84	30	51.[illegible]
T. 9 S., R. 2 W., corner secs. 9, 10, 15, and 16, T road east	41	41	40.3	84	32	00.[illegible]
Ohio-Michigan State line, center of north-south road	41	42	09.0	84	32	00.[illegible]
Pioneer, T road west, 1 mile east of, 30 feet northwest to cross cut on corner fence post, 42 feet southwest to cross cut on telephone pole	41	40	47.7	84	32	07.8
Pioneer, northeast corner of bridge at crossing of main streets	41	40	47.2	84	33	10.9
T. 9 S., R. 2 W., corner secs. 17, 18, 19, and 20, crossroads	41	40	47.6	84	34	20.2
T. 9 S., R. 2 W., west corner secs. 18 and 19, T road east	41	40	47.3	84	35	30.9
T. 9 S., R. 3 W., corner secs. 13, 14, 23, and 24, crossroads	41	40	46.9	84	36	40.9
T. 9 S., R. 3 W., corner secs. 14, 15, 22, and 23, at Bethel Church, crossroads	41	40	46.5	84	37	30.2
T. 9 S., R. 3 W., southeast corner sec. 10, 4 miles west and 1 mile north of Pioneer, in southeast corner of Osborne's farm, iron post stamped "Prim. Trav. Sta. No. 18, 1905"	41	41	39.0	84	37	30.6
Ohio-Michigan State line, T. 9 S., R. 3 W., 349 feet south of quarter corner between secs. 10 and 11	41	42	01.5	84	37	30.5
T. 9 S., R. 3 W., corner secs. 9, 10, 15, and 16, T road north	41	41	38.5	84	39	00.6
T. 9 S., R. 3 W., corner secs. 8, 9, 16, and 17, crossroads	41	41	38.1	84	40	10.7
T. 9 S., R. 3 W., north corner secs. 17 and 18, T road south	41	41	37.7	84	41	20.6
Northwest Church, T road north	41	41	36.3	84	43	04.8
In southeast corner of field owned by F. M. Husghy, iron post stamped "Prim. Trav. Sta. No. 19, 1905"	41	41	36.4	84	44	50.0
Ohio-Michigan State line, center of north-south road, 3 feet south of southwest gatepost	41	41	50.6	84	44	49.8

Geographic positions along highways near west border of quadrangle.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
T. 9 S., R. 4 W., corner secs. 14, 15, 22, and 23, crossroads	41	40	43.6	84	44	49.8
T. 9 S., R. 4 W., corner secs. 22, 23, 26, and 27, T road west	41	39	51.2	84	44	49.8
T. 9 S., R. 4 W., corner secs. 26, 27, 34, and 35, T road west	41	38	58.8	84	44	48.9
Tps. 9 and 10 S., R. 4 W., corner secs. 2, 3, 34, and 35, center of north-south road crossing at corner	41	38	06.4	84	44	47.8
T. 10 S., R. 4 W., south corner secs. 2 and 3, T road north	41	37	14.4	84	44	46.9
T. 8 N., R. 1 E., south corner secs. 33 and 34, crossroads	41	36	06.8	84	44	58.1
T. 7 N., R. 1 E., southwest corner sec. 3, in southwest corner of John Fox's garden; southwest corner of schoolhouse bears N. 79° 40′ W., distant 190.7 feet; southwest corner of section 3 bears S. 48° W., distant 30.7 feet; iron post stamped "Prim. Trav. Sta. No. 20, 1905"	41	35	06.7	84	44	57.4
T. 7 N., R. 1 E., corner secs. 9, 10, 15, and 16, crossroads	41	34	14.2	84	44	57.6
T. 7 N., R. 1 E., corner secs. 15, 16, 21, and 22, crossroads	41	33	22.2	84	44	57.6
T. 7 N., R. 1 E., corner secs. 21, 22, 27, and 28, crossroads	41	32	30.2	84	44	57.4
T. 7 N., R. 1 E., corner secs. 27, 28, 33, and 34, crossroads	41	31	38.2	84	44	57.1
Tps. 6 and 7 N., R. 1 E., corner secs. 3, 4, 33, and 34, stone	41	30	46.2	84	44	56.7

NEWARK QUADRANGLE (LICKING COUNTY).

Magnetic declination, west border, 0° 36′ west; north border, 2° 31′ west; east border, 3° 08′ west; south border, 1° 05′ west.

Geographic positions along highways.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Homer, 1.33 miles southeast of, large sugar maple in center of road	40	14	39.2	82	29	22.5
Road southwest, 24 feet south to cross on black oak	40	13	55.7	82	28	00.0
Utica, in southeast part, east-west road crossing Baltimore and Ohio R. R.	40	13	57.2	82	26	52.4
Licking-Knox county line, road west, 27 feet northwest to cross on gatepost, 27 feet southeast to cross on rail fence	40	14	35.8	82	25	04.2
Bell Church, 0.5 mile west of, T road north, 28 feet northwest to telephone pole, 22 feet southwest to cross on fence post	40	14	32.4	82	23	44.6
Martinsburg, 1.5 miles south of, at crossroads, in northeast corner of field of W. P. Harrison, iron post stamped "Prim. Trav. Sta. No. 41, 1905"	40	14	53.7	82	21	36.2
Martinsburg, about 2 miles southeast of, crossroads, 10 feet southeast to gum tree, 21 feet northeast to mail box	40	14	50.8	82	20	18.1
County line, 0.5 mile north of, crossing of east-west and northwest-southeast roads, 38 feet north to large white oak, 38 feet northeast to cross on fence post	40	14	49.6	82	19	14.8
County line, 0.5 mile north of, at A. J. Blount's farm, T road west, 29 feet northeast to cross on fence post, 30 feet southeast to cross on telegraph pole	40	14	48.6	82	17	06.4
Henpeck Corners, crossroads, 28 feet southeast to guidepost, 27 feet northwest to Benbow Simpkins's mail box	40	14	02.2	82	16	52.7
Henpeck Corners, 1 mile southeast of, 2 miles northwest of Fallsburg, just north of schoolhouse, in southeast corner of W. H. Kidd's farm, at T road northeast, iron post stamped "Prim. Trav. Sta. No. 42, 1905"	40	13	44.4	82	16	03.7
Fallsburg, 1 mile northwest of, T road east, scales, 200 feet north of, 16 feet east to Matt Frost's mail box	40	12	51.1	82	15	26.8
Corner secs. 14, 15, 16, and 17, cross on top of stone	40	11	56.0	82	15	46.1

Geographic positions along Toledo and Ohio Central Railway near Central City.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Milepost 28, 240 feet east of, east-west gravel-road crossing, north track.	40	01	43.1	82	29	25.[illegible]
Central City, 0.75 mile south of, 105 feet north of milepost 14, east-west gravel-road crossing	40	01	30.2	82	28	26.9
Milepost 13, just north of, private-road crossing	40	00	38.5	82	28	38.6

Geographic positions along highways.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Fulton schoolhouse, 0.25 mile east of, T road north, 22 feet south to cross on red gate	40	01	21.5	82	26	41.7
Lloyds Corners, 1 mile west of, T road south, 21 feet east to east end of tile culvert, 19 feet southwest to west end of same	40	00	54.1	82	25	34.5
Newark, about 3 miles south of, at Lloyds Corners, crossroads, 13 feet southeast to ring on telephone pole, 31 feet northeast to cross on picket fence	40	00	49.7	82	24	14.0
Lutheran Church, 1 mile northwest of, at top of hill, T road west, point on intersection	40	00	48.7	82	22	54.6
Newark, 4.5 miles southeast of, in Lutheran school grounds, southeast corner of schoolhouse foundation bears N. 25° 15′ W., distant 11.9 feet; northwest corner of Lutheran Church foundation bears S. 37° 30′ W., distant 67.6 feet; iron post stamped "Prim. Trav. Sta. No. 45, 1905"	40	00	16.6	82	22	04.8
Fry (John) farm, at southwest corner of, crossroads, 30 feet northeast to cross on post at south end of wire fence, 46 feet northwest to T. J. Moore's mail box	40	00	00.8	82	21	01.3
Sigler (R. S.) residence, T road south, 10 feet northeast to mail box, 30 feet southwest to guidepost	40	00	50.3	82	19	58.7
T. 1 N., R. 11 W., stone at corner secs. 1, 2, 9, and 10	40	00	46.1	82	18	34.3
Boodle schoolhouse, 1.33 miles southeast of, road south, 13 feet north to cross on gatepost, 36 feet southwest to mail box	40	00	04.8	82	16	57.9
Clay Lick, about 4 miles south of, in south part of grounds of Boodle schoolhouse, southwest corner of schoolhouse foundation bears N. 9° 15′ E., distant 57 feet, nail in root of maple tree bears N. 84° 30′ E., distant 60.1 feet; iron post stamped "Prim. Trav. Sta. No. 44, 1905".	40	00	58.7	82	17	23.4
Boodle schoolhouse, about 1.38 miles southeast of, road to south, 13 feet north to cross on gate-post, 36 feet southwest to mail box	40	00	04.8	82	16	57.9
Scott (G. W.) residence, intersection of roads, mail box	40	10	38.4	82	16	03.[illegible]
Sawmill, 900 feet north of, T road to west, on top of hill, 30 feet northwest to mail box	40	10	01.2	82	15	29.1
Reform, 0.66 mile northwest of, crossroads, 25 feet northeast to F. Priest's mail box, 29 feet northwest to cross on corner fence post	40	08	53.1	82	15	14.3
Reform crossroads, 21 feet southeast to R. S. Paine's mail box, 30 feet northeast to willow tree	40	08	16.6	82	15	02.0
Reform, 0.75 mile south of, in southwest corner of field of John W. Gardner, opposite Methodist Church, iron post stamped "Prim. Trav. Sta. No. 43, 1905"	40	07	34.0	82	15	05.0
Hanover, in northwest part of, road crossing under Pennsylvania R. R. center of	40	04	34.2	82	15	47.2
Hanover Electric R. R. station, road crossing, Newark and Zanesville Electric R. R	40	03	53.4	82	16	03.6
Clay Lick, 0.5 mile north of, just south of electric railroad station, old Ohio Canal, center of bridge over	40	03	54.0	82	17	27.7
Clay Lick, 1 mile south of, T road west	40	02	52.7	82	17	29.2
Clay Lick, 2 miles south of, road to southwest at Jonathan Intow's residence, 12 feet southwest to J. R. Shepherd's mail box	40	01	36.1	82	17	38.1

NEW COMERSTOWN QUADRANGLE (COSHOCTON AND GUERNSEY COUNTIES).

Magnetic declination, south border, 1° 57′ west.

Geographic positions along Pennsylvania Railroad between West Lafayette and Isleta.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
West Lafayette, 1 mile south of, T road east, 24 feet east to guidepost, "Plainfield 5 miles," 38 feet southeast to cross on corner fence post	40	15	29.8	81	44	27.6
West Lafayette, at northwest corner of public school grounds, northwest corner of schoolhouse bears S. 16° 15′ E., distant 256.6 feet; iron post stamped "Prim. Trav. Sta. No. 58, 1905"	40	16	33.3	81	44	50.2
Milepost 77, 300 feet east of, road crossing, north track	40	16	24.3	81	43	04.4
Milepost 78, 700 feet east of, north-south road crossing, south track	40	16	18.5	81	41	51.8
Isleta station, road crossing, south track	40	16	18.3	81	40	24.8

Geographic positions along highways.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Isleta, 1 mile southeast of, forks of road, 30 feet north to cross on board fence, 75 feet southeast to cross on telegraph pole	40	15	50.2	81	39	25.50
Top of hill, Y road at, 27 feet northeast to guidepost, "Coshocton 13 mi.," 21 feet west to mound	40	14	53.8	81	37	59.50
Widder triangulation station, on land of Chas. Widder, 2.5 miles nearly south of New Comerstown, 50 feet west of north-south road, 0.5 mile west of Baptist Church, and 600 feet southwest of White schoolhouse. Station mark: A sandstone post 36 by 6 by 6 inches, set 63 inches in the ground, in center of top of which is countersunk and cemented a bronze triangulation tablet (Ohio)	40	14	09.67	81	36	54.11

NEW LEXINGTON QUADRANGLES (MORGAN AND PERRY COUNTIES).

Geographic positions along highways.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Dovertown, cross streets, 48 feet northwest to southeast corner of post-office, 48 feet southwest to northeast corner of store at pump	39	44	03.1	82	02	16.7
T. 14 S., R. 14 W., north corner secs. 34 and 35	39	44	28.2	82	03	37.0
Dovertown station, road crossing Zanesville and Western Rwy	39	44	20.6	82	04	36.0
Stringtown crossroads, guidepost	39	44	39.5	82	05	18.1

Geographic positions along Cincinnati and Muskingum Valley Railroad between McLuney and New Lexington.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
McLuney, near station, on land of Charles Myers, southeast corner of station bears S. 71° W., distant 71.5 feet; northwest corner of store bears S. 81° 40′ E., distant 10 feet; iron post stamped "Prim. Trav. Sta. No. 65, 1905"	39	44	26.2	82	06	27.8
Lyondale station, road crossing	39	43	54.8	82	08	13.8
Milepost 35, 0.5 mile west of, north-south road crossing	39	43	29.1	82	09	47.6
Wilburn station, road crossing	39	43	26.7	82	10	38.1
New Lexington, 1 mile northeast of, north-south road crossing	39	43	16.0	82	11	45.6
New Lexington station, center of track opposite	39	43	08.7	82	13	00.0
Milepost 40, 900 feet west of, road crossing	39	43	20.9	82	14	35.7

OTTAWA QUADRANGLE (HENRY COUNTY).

Geographic positions along Baltimore and Ohio Southwestern Railroad between Holgate and Hamler.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Holgate, crossing of Baltimore and Ohio Southwestern R. R. and Clover Leaf Route	41	14	53.9	84	07	40.5
Holgate, 1 mile east of, in northwest corner of field at T road south, T. 3 N., R. 7 E., west quarter corner to sec. 6 is 30 feet west and 35 feet north of station; iron post stamped "Prim. Trav. Sta. No. 10, 1905"	41	14	46.0	84	06	47.7
Holgate, 2 miles east of, road crossing north and south	41	14	30.0	84	05	34.6
Hamler, 2.5 miles west of, section line, road crossing north and south	41	14	17.4	84	04	28.8
T. 3 N., R. 7 E., corner secs. 4, 5, 8, and 9, stone at crossroads	41	14	21.0	84	04	28.8
Hamler, 1.25 miles west of, road crossing north and south	41	14	04.1	84	03	18.9
Hamler, crossing of Baltimore and Ohio Southwestern and Detroit, Toledo and Ironton R. Rs	41	13	46.7	84	01	47.4
Road crossing northeast and southwest (south track)	41	13	31.1	84	00	25.4
T. 3 N., R. 8 E., sec. 7, northwest corner, iron post stamped "Prim. Trav. Sta. No. 11, 1905"	41	14	21.9	84	59	50.9

PAULDING QUADRANGLE (PAULDING COUNTY).

Geographic positions along highways near north border of quadrangle.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Section line, road crossing north and south	41	14	25.1	84	30	54.9
T. 3 N., R. 3 E., corner secs. 4, 5, 8, and 9, crossroads	41	14	15.6	84	32	02.7
T. 3 N., R. 3 E., corner secs. 5, 6, 7, and 8, crossroads	41	14	14.7	84	33	11.2
T. 3 N., Rs. 2 and 3 E., corner secs. 1, 6, 7, and 12, crossing Cincinnati Northern R. R. just east of	41	14	14.7	84	34	08.5
T road south	41	13	53.7	84	34	56.2
Cecil, crossroads 1 mile north of	41	13	51.2	84	36	05.9
T. 3 N., R. 2 E., center sec. 2, T road west	41	14	40.4	84	36	04.7

PHILO QUADRANGLE (MORGAN AND MUSKINGUM COUNTIES).

Magnetic declination, north border, 1° 52′ west; west border, 0° 51′ west; south border, 1° 04′ west, 1° 22′ west; east border, 1° 15′ west, 1° 38′ west.

Geographic positions along Baltimore and Ohio Railroad between Zanesville and Norwich.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Zanesville, 2 miles north of, Zanesville and Gilbert road just west of, between Baltimore and Ohio and Cincinnati and Muskingum Valley R. Rs., in southeast corner of field of Mrs. Margaret Clark, in stone post 10 by 12 by 33 inches, aluminum tablet stamped "Prim. Trav. Sta. No. 62, 1905"	39	58	42.2	81	58	55.0
Block station, just west of, overhead crossing	39	58	40.7	81	56	31.0
Milepost 65, center of track opposite	39	58	35.6	81	55	06.4
Sonora station, just northeast of, just inside of railroad right of way, northwest corner of J. A. Rush's residence bears S. 40° 45′ E., distant 25.5 feet; northeast corner of station bears S. 39° W., distant 87.8 feet; iron post stamped "Prim. Trav. Sta. No. 61, 1905"	39	59	02.3	81	54	12.4
Milepost 67, road crossing	39	59	25.7	81	53	27.4
Milepost 69, 0.75 mile west of, road crossing, warning post on north side of track	39	58	51.3	81	52	17.2
Bridgeville, 1 mile west of, road crossing under culvert	39	58	34.1	81	51	07.2
Bridgeville station, center of track opposite	39	58	54.4	81	50	05.4
Norwich station, 1.25 miles west of, national road crossing	39	58	39.5	81	48	48.3
Sundale station, center of track opposite	39	58	35.3	81	47	35.9
Sundale station, 0.75 mile east of, on north side of Baltimore and Ohio R. R. at north-south road crossing, in southwest corner of field owned by W. E. Dingley, center of railroad at road crossing bears S. 12° 30′ W., distant 48 feet; iron post stamped "Prim. Trav. Sta. No. 60, 1905"	39	58	54.0	81	46	47.1
Norwich, 0.5 mile east of, crossing of national road and north-south road, 33 feet northwest to cross on telephone pole, 54 feet south to corner yard fence	39	59	14.9	81	46	54.4
Wheeling and Lake Erie R. R. milepost 4, 400 feet south of, private-road crossing	39	59	35.3	81	56	52.1

Geographic positions along highways.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Pleasant Valley schoolhouse, 0.75 mile south of, T road north, 6 feet south to south end of culvert, 39 feet northwest to mail box on fence	39	47	35.5	81	45	39.2
Pleasant Valley, 0.5 mile north of, T road east, 13 feet northeast to elm snag, 27 feet west to cross on fence post	39	48	53.8	81	45	13.6
Snowball schoolhouse, 0.33 mile southeast of T road southwest, 15 feet north to cross on large corner fence post, 28 feet southeast to west end of box culvert	39	49	32.6	81	45	14.2
Highhill post-office, just north of, T road east, 16 feet southwest to cross on corner of stable, 33 feet northeast to "MF" cut on stonewall	39	50	00.8	81	46	04.4
Freeland, 1.5 miles south of, opposite Lee Warner's mail box, arrow painted on rail fence	39	51	33.4	81	46	16.2

Geographic positions along highways—Continued.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Freeland, in west corner of George Thorla's field, south rail of narrow-gage railroad bears N. 31° 45′ W., distant 38 feet; south corner of station bears N. 57° E., distant 152.3 feet; in stone post 12 by 12 by 36 inches, marked "U. S. G. S.," stamped "Prim. Trav. Sta. No. 69".	39	52	51.2	81	46	31.7
Center of bridge	39	53	43.9	81	45	34.0
Rich Hill, Methodist Church, T road southeast, 10 feet northwest to cross on telegraph pole, 28 feet southeast to guidepost ("Rexs Mill 1.5 mi.")	39	54	33.9	81	45	12.1
Rexs Mill, 0.25 mile southeast of, T road west, 32 feet west to cross on fence post, 27 feet southwest to cross on gate post	39	55	19.0	81	44	29.5
Rexs Mill, 1 mile northwest of, crossroads, 21 feet northwest to Lee Davis's mail box, 22 feet northeast to cross on telegraph pole	39	56	14.0	81	45	14.0
Sundale, 1.25 miles east by 0.25 mile south of, T road south, 22 feet southeast to cross on corner fence post, 45 feet north to cross on board fence	39	58	11.0	81	45	57.3

Geographic positions along Ohio and Little Kanawha Railroad between Brush Creek and Dillon.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Brush Creek bridge, about 1 mile northwest of, 0.25 mile southeast of coal-mine shaft, road crossing	39	53	22.1	81	59	42.6
Brush Creek station, in northeast corner of A. M. Shylock's field, 24 feet north to south rail of Ohio and Little Kanawha R. R., 31 feet east to center of north-south road, iron post stamped "Prim. Trav. Sta. No. 63, 1905"	39	52	41.4	81	58	50.9
Brush Creek bridge, 0.75 mile south of, overhead road crossing	39	52	02.8	81	59	00.9
Ohio and Little Kanawha R. R. milepost 3, 0.33 mile north of, north-south road crossing	39	51	15.2	81	59	07.3
Stovetown, road crossing at station	39	50	19.6	81	59	12.0
Milepost 1, road crossing	39	49	28.6	81	59	06.8
Connelsville station, Dillon post-office, just east of, street crossing railroad	39	48	48.9	81	59	46.0

Geographic positions along highways from Dillon post-office to a point 1.75 miles north of Rowland post-office.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Dillon post-office, 1 mile southeast of, T road west at large elm tree, 15 feet southwest to elm tree, 29 feet northeast to corner fence post	39	48	16.4	81	59	15.9
Forks of road, 17 feet north to cross on telegraph pole, 22 feet east to mail box No. 46	39	47	25.2	81	58	57.9
Bailey Church and schoolhouse, 0.25 mile north of, T road south, 24 feet east to small walnut tree, 35 feet southwest to cross on fence post.	39	45	21.5	81	59	13.8
Sharp Hill schoolhouse, 0.25 mile east of, T road south, 35 feet southwest to cross on corner fence post, 21 feet northeast to wild-cherry tree	39	45	39.4	81	56	46.3
Duront, 0.75 mile west of, T road north, arrow painted on Lewis Fouta's yard fence	39	44	57.2	81	55	37.4
Duront, W. H. Stokes's front yard, south corner of fence bears N. 10° 45′ W., distant 29.7 feet; iron post stamped "Prim. Trav. Sta. No. 67, 1905"	39	45	02.9	81	54	48.5
At corner of apple orchard, T road north, 30 feet to cross on board fence, 28 feet east to cross on fence post	39	45	03.2	81	53	33.4
Duront, 2 miles east of, T. 11 S., R. 12 W., corner secs. 3, 4, 9, and 10, stone	39	44	53.7	81	52	19.3
Brick house, T road west, cross on corner fence post	39	45	10.7	81	50	40.2
Sewall's (John) residence, T road east, 24 feet north to cross on fence post, 45 feet west to cross on corner of outbuilding	39	45	30.3	81	49	29.2
Sewall's (John) residence, 1 mile east of, T road southwest, 28 feet south to cross on gate post, 36 feet west to corner of hedge fence	39	45	12.0	81	48	31.8
Rowland post-office, 0.5 mile north of, at T road west, in northeast corner of Walton Blackledge's field; iron post stamped "Prim. Trav. Sta. No. 68, 1905"	39	45	04.2	81	46	21.5
Rowland, 1.75 miles north of, T road southeast, 19 feet south to mail box, 24 feet northeast to large dead tree	39	45	59.2	81	45	55.2

STRYKER QUADRANGLE (FULTON AND WILLIAMS COUNTIES).

Geographic positions along highways on west border of quadrangle.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
T. 6 N., R. 3 E., north corner secs. 1 and 2, T road south	41	30	49.4	84	28	36.7
T. 7 N., R. 3 E., corner secs. 25, 26, 35, and 36, crossroads	41	31	41.7	84	28	39.5
T. 7 N., R. 3 E., corner secs. 23, 24, 25, and 26, 0.5 mile north of, T road south	41	33	00.1	84	28	39.2
T. 7 N., R. 3 E., corner secs. 14, 15, 22, and 23, T road east	41	33	26.7	84	29	45.1
T. 7 N., R. 3 E., corner secs. 10, 11, 14, and 15	41	34	18.9	84	29	47.9
T. 7 N., R. 3 E., corner secs. 2, 3, 10, and 11, crossroads	41	35	11.1	84	29	48.0
T. 8 N., R. 3 E., southwest corner sec. 35, in southwest corner of field of Joseph Eberly, northwest corner of his house bears S. 2° E., distant 91.4 feet; southwest corner of Warnick's house bears N. 74° W., distant 76.4 feet; iron post stamped "Prim. Trav. Sta. No. 16, 1905".	41	36	02.4	84	29	40.4
T. 8 N., R. 3 E., north corner secs. 34 and 35	41	36	54.3	84	29	50.1
T. 10 S., R. 2 W., south corner secs. 1 and 2, crossroads	41	37	18.7	84	29	43.0
T. 9 S., R. 2 W., corner secs. 25, 26, 35, and 36, crossroads	41	39	03.4	84	29	42.7
T. 9 S., R. 2 W., corner secs. 23, 24, 25, and 26, crossroads	41	39	56.1	84	29	42.7
T. 9 S., R. 2 W., corner secs. 13, 14, 23, and 24, crossroads	41	40	48.6	84	29	42.4

Geographic positions along highways on north border of quadrangle near Ohio-Michigan State line.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
T. 9 S., R. 2 W., in southeast corner sec. 11, in southeast corner of field of E. Thatcher, iron post stamped "Prim. Trav. Sta. No. 17, 1905"	41	41	41.3	84	29	41.6
T. 9 S., R. 2 W., east corner secs. 12 and 13, T road west	41	41	39.9	84	28	32.0
T. 9 S., R. 1 W., corner secs. 7, 8, 17, and 18, crossroads	41	41	40.7	84	27	22.7
T. 9 S., R. 1 W., corner secs. 8, 9, 16, and 17, T road south	41	41	41.0	84	26	14.8
Ohio-Michigan State line, 0.33 mile west of Cincinnati Northern R. R., T road south	41	42	17.6	84	25	40.5
Ohio-Michigan State line, 0.75 mile east of Cincinnati Northern R. R., crossroads	41	42	19.2	84	24	31.9
T. 9 S., R. 1 W., corner secs. 10, 11, 14, and 15, Fulton-Williams county line	41	41	41.5	84	23	56.6
T. 9 S., R. 1 W., southeast corner sec. 11, in southeast corner of field of G. S. Wilnor, iron post stamped "Prim. Trav. Sta. No. 23, 1905"	41	41	41.6	84	22	47.3
T. 9 S., R. 1 W., east corner of secs. 12 and 13, T road west	41	41	42.0	84	21	36.2
T. 9 S., R. 1 E., corner secs. 7, 8, 17, and 18, crossroad	41	41	41.9	84	19	40.6
T. 9 S., R. 1 E., corner secs. 8, 9, 16, and 17, crossroad	41	41	43.7	84	18	23.5
T. 9 S., R. 1 E., corner secs. 9, 10, 15, and 16, crossroad	41	41	45.3	84	17	19.7
T. 9 S., R. 1 E., corner secs. 10, 11, 14, and 15, crossroad	41	41	45.6	84	16	08.9
Ohio-Michigan State line, center of north-south road	41	42	31.7	84	16	11.0
Ritters, 1.5 miles southeast of, in northwest corner of Hewey Sutton's front yard; northwest corner of Sutton's house bears S. 79° E., distant 181.2 feet; east rail of electric railway at crossing bears N. 67° W., distant 69 feet; iron post stamped "Prim. Trav. Sta. No. 24, 1905".	41	41	46.8	84	14	56.7

SUGARGROVE QUADRANGLE (FAIRFIELD COUNTY).

Geographic positions along Hocking Valley Railway between Lancaster and Hooker.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Pleasant triangulation station (2), on the summit of a bluff locally called Mount Pleasant, about 300 feet above and 1 mile north of Lancaster, Ohio, immediately east of fairgrounds, on land of F. J. Buschemeyer. Station mark: Center of iron windmill near west end of summit. Reference mark: A triangle cut in sandstone ledge, with arrows cut on edge of bluff pointing to station. Azimuth from station to center of windmill, 148° 23′, distance, 228 feet	39	43	30.56	82	35	42.36
Lancaster, crossing of Fair avenue and Columbus street	39	43	26.4	82	36	15.10
Lancaster, 1.6 miles northwest of, pike crossing Hocking Valley Rwy., east track, township line follows railroad northwest	39	43	30.1	82	37	40.60
Water tank, spout between tracks	39	44	16.1	82	38	43.30
Hooker station, 350 feet northwest of, on north side of east-west road, near southeast corner of field of Mike Vase; southwest corner of foundation to house bears N. 43° 15′ E., distant 29 feet; iron post stamped "Prim. Trav. Sta. No. 48, 1905"	39	44	51.5	82	39	47.60

Geographic positions along highways.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Hooker, 1.75 miles west of, 22 feet northwest to R. V. Allen's mail box, 25 feet northeast to cross on fence post	39	44	52.7	82	41	51.7
Hooker, 3 miles west of, at crossroads, in east part of field owned by Jacob Bookmon, near apple tree on top of steep bank west of intersection of crossroads, iron post stamped "Prim. Trav. Sta. No. 49, 1905"	39	44	59.3	82	42	47.1

SWANTON QUADRANGLE (FULTON AND LUCAS COUNTIES).

Geographic positions along highways near north border of quadrangle.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Seward, 2 miles east by 0.5 mile north of, at crossing of township-line road with Lyons-Metamora road, in northwest corner of field of Adam Math, iron post stamped "Prim. Trav. Sta. No. 25, 1905"	41	42	33.7	83	59	53.2
Whiteville, crossroads, 20 feet southwest to E. J. Smith's mail box, 36 feet north to road crossing of T. and W. electric road	41	42	40.3	83	58	34.9
Whiteville, T road north 1 mile east of, 27 feet north to road crossing of T. and W. electric road, 24 feet east to Peter Myer's mail box	41	42	45.5	83	57	25.9
Whiteville, T road north 2 miles east of, at stop 27, 39 feet north to road crossing of electric railroad	41	42	51.0	83	56	15.4
Ohio-Michigan State line, crossing north-south road	41	43	05.9	83	56	16.0
Metamora, center of bridge over creek in	41	42	41.2	83	54	38.0
In south part of schoolhouse yard at county line; north rail of electric road at switch block bears S. 49° 30′ E., distant 126 feet; southeast corner of schoolhouse bears N. 0° 15′ E., distant 78 feet; iron post stamped "Prim. Trav. Sta. No. 26, 1905"	41	42	42.6	83	52	48.3
Berky, crossroads at stop 55, 1 mile west of, 33 feet west to mail box, 30 feet southwest to south end of culvert	41	43	01.5	83	51	31.9
Berky, crossroads, 33 feet southeast to crossing of T. and W. electric road	41	42	54.2	83	50	21.9
Berky, crossing north-south road and electric road 1 mile east of	41	42	48.5	83	49	11.9
Berky, T road north 2 miles east of	41	42	55.7	83	48	05.6
T. 9 S., R. 5 E., sec. 11, northeast part of, 0.25 mile west of electric-railroad junction, in northeast corner of field owned by John S. Clark, at T road south, iron post stamped "Prim. Trav. Sta. No. 27, 1905"	41	42	56.3	83	47	11.7
Ohio-Michigan State line	41	43	19.8	83	48	06.6
T. 9 S., R. 5 E., corner secs. 11, 12, 13, and 14, 0.25 mile west of, mail box of Kate R. Van Norman and Paul Taior, crossroads	41	42	05.8	83	47	09.2

Geographic positions along highways near east border of quadrangle.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
T. 9 S., R. 5 E., secs. 13, 14, 23, and 24, crossroads 0.25 mile west of, 19 feet northeast to John G. Taylor's mail box, 18 feet north to east end of small bridge	41	41	12.4	83	47	07.9
T. 9 S., R. 5 E., secs. 23, 24, 25, and 26, T road north 0.25 mile west of, 30 feet north to C. Lochrihler's mail box, 27 feet northeast to east end of stone culvert	41	40	22.7	83	47	05.4
T. 95 N., R. 5 E., corner secs. 22, 23, 26, and 27, T road north, 24 feet northeast to cross on telephone pole, 21 feet northwest to west end of stone culvert	41	40	22.5	83	47	42.9
T. 9 S., R. 5 E., corner secs. 21, 22, 27, and 28, 33 feet southwest to cross on telephone pole, 38 feet southeast to corner fence post, T road south	41	40	21.7	83	49	07.3
T. 9 S., R. 5 E., corner secs. 27, 28, 33, and 34, crossroads, 21 feet west to center of bridge, 36 feet northeast to southwest corner of pool hall	41	39	27.4	83	49	05.6
T. 9 S., R. 5 E., south corner secs. 33 and 34, stone at T road north	41	38	35.9	83	49	03.9
T. 10 S., R. 5 E., corner secs. 3, 4, 9, and 10, 32 feet northwest to cross on telephone pole, 31 feet southeast to J. K. Barnes's mail box	41	37	45.2	83	49	02.3
T road north at Oak Grove schoolhouse, 18 feet northeast to J. R. Bower's mail box, 36 feet northwest to arrow on post	41	37	00.9	83	49	00.6
Holland, 4 miles west of, 0.33 mile south of Lake Shore and Michigan Southern Rwy., at crossroads, iron post stamped "Prim. Trav. Sta. No. 28, 1905"	41	36	01.0	83	47	34.8
T. 7 N., R. 5 E., secs. 11 and 12, quarter corner between, T road east, stone at intersection of road	41	34	55.0	83	47	10.5

Geographic positions along highways near east border of triangle—Continued.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
T. 7 N., R. 5 E., east corner secs. 14 and 23, T road west, 21 feet northwest to northeast corner of stone culvert, 23 feet southwest to southeast corner of same culvert	41	33	36.8	83	47	09.8
T. 7 N., R. 5 E., corner secs. 23, 24, 25, and 26, crossroads at schoolhouse, 25 feet northeast to mail box on post, 33 feet northwest to maple tree at corner of fence	41	32	44.0	83	47	09.4
T. 7 N., R. 5 E., south corner secs. 35 and 36, stone to, T road north..	41	30	59.4	83	47	09.2
Watervile, 3.5 miles west of, on Waterville-Neapolis pike, T road north, in southeast corner of field of John Lichales, iron post stamped "Prim. Trav. Sta. No. 29, 1905"	41	29	43.8	83	46	58.6
Waterville, 2 miles west of, crossroads at schoolhouse, 44 feet southwest to guidepost, 48 feet southeast to iron pump	41	29	44.1	83	46	00.9
Waterville station, east-west pike crossing of Clover Leaf Route about 800 feet southwest of	41	29	55.9	83	43	35.5

THORNVILLE QUADRANGLE (FAIRFIELD, LICKING, AND PERRY COUNTIES).

Magnetic declination, north border, 1° 05′ west; south border, 0° 37′ west; west border, 0° 15′ west; east border, 1° 22′ west.

Geographic positions along Baltimore and Ohio Railroad between milepost 28 and Chalfont.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Milepost 28, 2,000 feet north of, private-road crossing	39	45	47.3	82	18	55.7
Wellom station, east-west road crossing	39	46	34.8	82	18	42.3
Road crossing under trestle	39	47	27.2	82	18	30.6
Somerset, 0.5 mile south of station, overhead crossing	39	48	18.8	82	17	51.7
Brick plant, switch block to spur	39	49	25.0	82	17	19.4
Milepost 22, 495 feet north of, east-west road crossing	39	50	17.6	82	16	43.2
Milepost 21, 440 feet north of, road crossing	39	51	08.6	82	16	48.0
Chalfont station, east-west road crossing in southwest corner of field of N. S. Axline, center of road crossing bears S. 60° 15′ W., distant 33 feet; iron post stamped "Prim. Trav. Sta. No. 52, 1905"	39	52	08.7	82	17	11.0

Geographic positions along Zanesville and Western Railway near Glassrock.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Glassrock station, north-south road crossing railroad	39	52	36.7	82	17	22.0
Milepost 21, 0.5 mile east of, north-south road crossing	39	52	34.7	82	16	06.9
Glassrock station, 2 miles east of, railroad bridge over Jonathan Creek, north-south road crossing, 800 feet east of	39	52	39.8	82	15	06.9

Geographic positions along highways.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
On top of hill and T road east, G. Hartsough's mail box	39	53	57.9	82	15	16.8
Corner secs. 13 and 14 (?) on Licking-Perry county line, rail fence west along north edge of woods, 19 feet west to cross on fence post	39	54	50.5	82	15	12.8
Brownsville, 1 mile south of, crossroads, cross on corner fence post	39	55	44.8	82	15	43.2
Brownsville, Davy Hotel, just west of, T road north, 35 feet northwest to guidepost, 39 feet southeast to cross on telegraph pole	39	56	49.6	82	15	28.1
Brownsville, 3 miles north of, at Clark's blacksmith shop, crossroads, guidepost	39	59	21.2	82	15	48.9
Boodle schoolhouse, 1.33 miles southeast of, road south, 13 feet north to cross on gatepost, 36 feet southwest to mail box	40	00	04.8	82	16	57.9

Geographic positions along Toledo and Ohio Central Railway near Hebron.

Station.	Latitude.			Longitude		
	°	′	″	°	′	″
Milepost 13, just north of, private-road crossing	40	00	38.5	82	28	38.8
Trestle No. 1364 over northeast-southwest gravel road, center of	39	59	27.9	82	28	48.9
Hebron, crossing of Toledo and Ohio Central and C., N. and Z. electric road	39	57	41.2	82	29	34.1

Geographic positions along highways.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Baptist Corners, 1 mile east of, center of bridge at crossroads	39	46	31.1	82	29	20.4
West Rushville, crossroads, 46 feet southwest to northeast corner of Dilger Bros.' store, 63 feet southeast to John Dilger's store	39	45	48.9	82	26	51.8
Rushville, crossroads at Ruchville Hotel, center of intersection	39	45	52.6	82	25	54.5
Rushville, 1.1 miles east of, T road north, 27 feet northwest to cross on fence post, 27 feet southwest to cross on telegraph pole	39	46	01.2	82	24	41.3
Perry-Fairfield county line, T road south	39	46	06.4	82	24	06.9
Rushville, 2.5 miles east of, 2 miles north of Avlon, at crossroads, in southeast corner of John Love's farm; southwest corner of Thos. Griffin's residence bears N. 59° E., distant 45.6 feet; iron post stamped "Prim. Trav. Sta. No. 51, 1905"	39	46	06.6	82	22	57.9
Ottoman, United Brethren Church, 0.25 mile south of, crossroads, 10 feet west to cross on corner fence post, 24 feet to cross on corner post in wire fence	39	46	09.9	82	21	47.4
Top of hill, T road east, 15 feet southeast to Henry Brehm's mail box	39	45	50.1	82	21	06.8
Shoal House, T road west, 12 feet east to cross on small locust tree, 32 feet northwest to southeast corner of coal shed	39	45	21.4	82	20	34.8

THURSTON QUADRANGLE (FAIRFIELD AND LICKING COUNTIES).

Magnetic declination, west border, 0° 31″ west.

Geographic positions along Baltimore and Ohio Railroad, Summit to Outville.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Summit, road crossing at station, north track	39	59	52.6	82	45	07.5
Summit station, 1 mile east of, north track at north-south road crossing	39	59	50.7	82	43	45.4
Summit, 2 miles east of station, north track at east-west road crossing	39	59	49.3	82	42	43.4
Columbia Center, north-south road crossing	39	59	48.0	82	41	49.6
Pataskala, street crossing east of station	39	59	46.2	82	40	31.1
Pataskala, 1.5 miles east of, at road crossing Pennsylvania R. R., in southeast corner of field of Edward Condit; north rail of north track at road crossing bears S. 20° 30′ E., distant 60 feet; iron post stamped "Prim. Trav. Sta. No. 35, 1905"	39	59	44.2	82	38	41.5
Pataskala, 2.5 miles east of, south track at road crossing	39	59	41.9	82	37	32.6
Outville, north-south road crossing	39	59	39.6	82	35	48.4
Outville, 1 mile east of, north track at north-south road crossing	39	59	44.0	82	34	40.4

Geographic positions along Toledo and Ohio Central Railway, Outville to Pleasantville.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Milepost 8, center of track opposite	39	56	49.4	82	30	36.6
Licking-Fairfield county line, east-west road crossing	39	55	38.6	82	31	15.1
Millersport, 1 mile north of, water tank, center of track	39	54	42.6	82	31	43.7
Millersport, near bridge, in south part of lot owned by Pence & Swisher, 47 feet due west to east rail; cross on corner of bridge abutment bears S. 54° 45′ W., distant 54.7 feet; iron post stamped "Prim. Trav. Sta. No. 46, 1905"	39	53	57.7	82	32	12.9
Millersport, 2 miles south of, east-west gravel road crossing	39	52	10.2	82	32	32.8
Thurston, crossing of Zanesville and Western and Toledo and Ohio Central Rwys	39	50	48.2	82	32	39.7
Thurston, 1.2 miles south of, center of track at east-west road crossing	39	49	28.3	82	31	45.9
Thurston, 1.2 miles south of, T. 16 S., R. 18 W., corner secs. 27, 28, 33, and 34, 610 feet west of east-west road crossing	39	49	28.3	82	31	53.8
Pleasantville, township line, road crossing	39	48	33.2	82	31	02.4

Geographic positions along highways, Pleasantville to a point 5 miles west of Zinc schoolhouse.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Pleasantville, 1.33 miles east of, crossroads at schoolhouse, 33 feet northeast to cross on telegraph pole, 38 feet northwest to cross on corner fence post	39	47	51.7	82	30	23.5
Schoolhouse, 1 mile south of, T road east, 24 feet northeast to granite bowlder, 39 feet southeast to locust tree	39	46	55.8	82	30	28.5
Pleasantville, 2.5 miles south and 0.5 mile east of, in southeast corner of Baptist schoolhouse yard; pump bears west, distant 11 feet; southeast corner of schoolhouse bears N. 44° 20′ W., distant 25.7 feet; iron post stamped "Prim. Trav. Sta. No. 47, 1905"	39	46	22.1	82	30	22.5
Bridge over creek, 700 feet east of, T road south just east of J. G. Mertz's mail box	39	45	57.2	82	31	44.8
T. 15 S., R. 18 W., secs. 16, 17, 20, and 21, corner of stone and T road north	39	46	01.5	82	33	31.2
Lancaster, 3.5 miles north of, Friesner's nursery, crossroads, 30 feet northwest to cross on telegraph pole	39	46	04.0	82	34	35.9
Zinc schoolhouse, crossroads, 19 feet south to large elm tree	39	45	09.2	82	35	01.1
T road west at corner of sections (no numbers)	39	45	34.2	82	42	43.6
Gravel pit, crossroads, 33 feet northeast to cross on board fence, 34 feet northwest to cross on corner fence post	39	46	24.3	82	42	15.4

Geographic positions along Hocking Valley Railway.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Carroll station, 0.5 mile southeast of, north-south road crossing railroad	39	47	33.8	82	42	08.7
Carroll station, east-west road crossing	39	48	00.6	82	42	35.6
Little Walnut Creek, 0.25 mile south of, east-west road crossing	39	49	06.6	82	43	04.2
Sherman schoolhouse, 1 mile south of, north-south road crossing	39	49	45.2	82	43	38.5

Geographic positions along highways, Sherman to district No. 10 schoolhouse.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Sherman schoolhouse, crossroads, 35 feet southwest to walnut tree, 23 feet southeast to cross on telegraph pole	39	50	27.3	82	43	27.2
Sherman schoolhouse, 1 mile north of, crossroads, 30 feet northeast to mail box, 26 feet southeast to cross on fence post	39	51	20.6	82	43	12.6
T. 15 S., R. 20 W., corner secs. 13, 14, 23, and 24	39	51	47.4	82	43	30.4
T. 15 S., R. 20 W., secs. 11, 12, 13, and 14, crossroads, 24 feet southwest to mail box on fence post, 24 feet northwest to cross on telegraph pole	39	52	30.4	82	43	16.1
T. 15 S., R. 20 W., northwest corner sec. 12, at T road south, in northwest corner of Wm. Hay's pasture; nail in root of small cherry tree bears S. 6° E., distant 13.4 feet; iron post stamped "Prim. Trav. Sta. 50, 1905"	39	53	32.6	82	43	11.4
Violet Chapel, 0.25 mile north of, forks of road, 19 feet northwest to cross on gatepost, 21 feet southeast to cross on large fence post	39	54	36.8	82	43	42.4
Violet Chapel, 1.5 miles north of, stone at crossroads	39	55	46.7	82	43	35.9
Wagram, 1 mile south of, crossroads, 23 feet southeast to corner of rail fence, 24 feet northeast to bowlder at end of hedge fence	39	56	40.6	82	43	51.3
Wagram, at post-office, north-south road crossing of C., N. and Z. electric railway	39	57	24.6	82	43	38.1
Wagram, 1.25 miles west of, T road north, 24 feet northeast to cross on board fence, 40 feet northwest to guidepost	39	57	23.4	82	45	11.1
Schoolhouse, district No. 10, T road south, Philip Krunnas's mail box	39	58	31.3	82	45	05.4

WAUSEON QUADRANGLE (FULTON COUNTY).

Geographic positions along highways on south border of quadrangle.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
T. 6 N., R. 7 E., northeast corner, sec. 13, at crossroads, in northeast corner of orchard owned by Edna Cline, iron post stamped "Prim. Trav. Sta. No. 31, 1905"	41	29	10.5	84	00	30.7
T. 6 N., R. 7 E., north corner secs. 11 and 12, T road south, 31 feet southwest to cross on corner fence post, 30 feet northwest to E. M. Smith's mail box	41	29	10.9	84	01	05.5
T. 6 N., R. 7 E., corner secs. 10, 11, 14, and 15, crossroads, 33 feet southwest to end of wire fence, 37 feet northwest to cross on gatepost	41	29	11.5	84	02	15.2
T. 6 N., R. 7 E., corner secs. 2, 3, 10, and 11, crossroads, 22 feet southwest to south end of culvert, 41 feet southeast to cross on corner fence post	41	30	03.9	84	02	14.9
T. 6 N., R. 7 E., corner secs. 3, 4, 9, and 10, crossroads, 39 feet southeast to cross on corner fence post, 45 feet southwest to G. S. Frederick's mail box	41	30	01.2	84	03	13.8
T. 6 N., R. 7 E., corner secs. 4, 5, 8, and 9, crossroads, 34 feet southeast to cross on corner fence post, 48 feet southwest to cross on fence post	41	30	01.1	84	04	34.8
T. 6 N., R. 7 E., corner secs. 5, 6, 7, and 8, crossroads at schoolhouse, 33 feet northeast to T. L. Ammand's mail box, 35 feet northwest to cross on telephone pole	41	30	00.9	84	05	43.8
T. 6 N., R. 6 E., east corner secs. 1 and 12, 31 feet northwest to Val Snyder's mail box, 34 feet southwest to corner of rail fence	41	30	02.0	84	06	52.5
T. 6 N., R. 6 E., southwest corner sec. 1, in southwest corner schoolhouse No. 3 yard, crossroads, southwest corner of schoolhouse bears N. 16° 10′ E., distant 171.4 feet; northwest corner foundation of church bears S. 2° 30′ E., distant 79.9 feet, iron post stamped "Prim. Trav. Sta. No. 32, 1905"	41	30	01.7	84	08	02.0
T. 6 N., R. 6 E., corner secs. 2, 3, 10, and 11, crossroads, 34 feet southeast to cross on corner fence post, 36 feet northeast to cross on yard fence post	41	30	01.3	84	09	12.0
T. 6 N., R. 6 E., corner secs. 3, 4, 9, and 10, crossroads, 34 feet southeast to cross on telephone pole, 39 feet northeast to penalty notice	41	30	01.2	84	10	21.7
T. 6 N., R. 6 E., corner secs. 4, 5, 8, and 9, crossroads, 12 feet southeast to cross on telephone pole, 29 feet southwest to Frank Lea's mail box	41	30	00.0	84	11	30.1
T. 6 N., R. 6 E., corner secs. 5, 6, 7, and 8, at schoolhouse, crossroads, 28 feet southwest to David Reyze's mail box, 43 feet northeast to iron fence	41	30	00.3	84	12	41.1
T. 6 N., R. 5 W., east corner secs. 1 and 12, 33 feet southwest to corner of garden fence, 32 feet northwest to cross on advertising board	41	30	00.6	84	13	44.0
T. 6 N., R. 5 E., southeast corner sec. 2, in southeast corner of yard of district No. 14 schoolhouse, center of iron pump in yard bears N. 82° W., distant 42 feet; southeast corner of schoolhouse bears N. 45° W., distant 44.7 feet	41	30	00.8	84	14	54.0

ZANESVILLE QUADRANGLE (LICKING AND MUSKINGUM COUNTIES).

Magnetic declination, west border, 1° 22′ west; east border, 0° 51′ west.

Geographic positions along highways.

Station.	Latitude.			Longitude.		
	°	′	″	°	″	′
Gratiot, 2.5 miles north of, 2.5 miles east of Clark's blacksmith shop, T road south, 30 feet southeast to large chestnut tree, 17 feet northeast to cross on rail fence	39	59	05.1	82	13	15.9
Licking-Muskingum county line, rail fence north and south, center of road, 25 feet south to west end of hedge fence	39	59	12.2	82	11	48.5
G. W. Fisher's mail box at Newark, road to northwest	39	59	16.6	82	11	05.7
J. Riggles's mail box, center of small bridge	39	59	24.1	82	10	08.7
E. T. Smith's mail box, southeast corner of iron bridge	39	59	53.0	82	09	20.8
Pleasant Valley station, 2 miles southwest of, just south of Mapdonia Church; in northeast corner of lot, in front of S. W. Wincia's residence, iron post stamped "Prim. Trav. Sta. No. 53, 1905"	39	59	47.1	82	08	24.2

Geographic positions along Baltimore and Ohio Railroad near Dillon.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Milepost 84, 900 feet west of, private-road crossing	39	59	38.0	82	05	07.9
Milepost 83, center of track opposite	39	58	57.7	82	04	09.9
Dillon station, road crossing	39	58	17.0	82	03	30.6

Geographic positions along highways.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Dillon, 0.75 mile north of station, on east side of river, T road east, 25 feet southeast to cross on board fence, 27 feet northeast to cross on corner fence post	39	58	49.6	82	03	05.[illegible]
Harris's farm, crossing of Frostburg road and east-west road, 33 feet southwest to cross on telegraph pole, 27 feet northeast to cross on telegraph pole	39	58	46.5	82	01	01.5
Zanesville, 3 miles north of, J. N. Blair's farm, T road west, 33 feet northwest to cross on board fence, 16 feet east to cross on gatepost	39	58	45.0	82	00	14.7

Geographic positions along Wheeling and Lake Erie Railroad, near Zanesville.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Zanesville, Monroe Street Bridge over railroad	39	57	05.5	82	00	06.0
Licking Creek, center of terminal railway bridge over	39	56	30.6	82	01	23.1
Owen (J. B.) Pottery Co.'s plant, just south of, road crossing under trestle	39	55	35.4	82	01	43.6
Jonathan Creek, road crossing just north of bridge over	39	54	15.9	82	00	14.4

Geographic positions along highways.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Muskingum-Morgan county line, center of road at, 30 feet due east to dead beech tree at corner of fence	39	46	05.9	82	00	15.6
Morgan County line, 0.33 mile south of, stone at crossroads, 25 feet south to cross on fence post, 54 feet northeast to corner of barn	39	45	50.7	82	00	20.6
Muskingum-Morgan county line, 0.5 mile south of, in southeast corner of foundation to brick house of N. H. Pletcher on the Dillon-Dovertown road, aluminum tablet stamped "Prim. Trav. Sta. No. 64, 1905"	39	45	43.0	82	00	31.1
Dovertown 1.5 miles northeast of, at Charles Bush's residence, T road east, 40 feet to C. A. Pletcher's mail box, 9 feet south to west end of box culvert	39	45	01.4	82	01	18.7

PENNSYLVANIA-NEW YORK.

TRIANGULATION STATIONS.

WARREN COUNTY, PA.; CHAUTAUQUA COUNTY, N. Y.

WARREN AND YOUNGSVILLE QUADRANGLES.

During the summer of 1905 E. L. McNair, topographer, located eight new stations for the control of these two quadrangles, one of these stations being in Chautauqua County, N. Y., near the State line. This triangulation was based on Meas and Busti, two stations of the Geological Survey in Chautauqua County, N. Y., established by A. H. Thompson in 1902.

BUSTI, CHAUTAUQUA COUNTY, N. Y.

In the southeast corner of Busti Township, about 2 miles a little east of south from the village of Busti, on a commanding ridge on land owned by C. Meredith.

Station mark: A stone post 30 by 6 by 6 inches set 28 inches in the ground, in the center of top of which is cemented a bronze triangulation tablet.

[Latitude 42° 00′ 32.55″. Longitude, 79° 16′ 25.26″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Panama	108	08	36. 83	287	58	46. 96	4. 3286072
Meas	194	05	59. 78	14	07	45. 77	4. 1734905
Highland	201	20	39. 98	21	25	02. 32	4. 4000139
Walrod	227	50	04. 10	47	56	24. 17	4. 2451027
Peterson	254	30	43. 27	74	38	04. 93	4. 1970889
Nelson	341	12	36. 14	161	13	42. 13	3. 8485040

MEAS, CHAUTAUQUA COUNTY, N. Y.

Near the center of Ellicott Township, on a high ridge about 3 miles north of Jamestown and one-third mile south of the Jamestown-Ross Mills road, on land owned by P. A. Melonist.

Station mark: A stone post 40 by 6 by 6 inches set 36 inches in the ground and having a bronze tablet cemented in its top.

[Latitude 42° 08′ 21.22″. Longitude 79° 13′ 47.09″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Nelson	3	42	36. 51	183	41	56. 66	4. 3260087
Busti	14	07	45. 77	194	05	59. 78	4. 1734905
Panama	71	53	22. 33	251	41	45. 66	4. 4002458
Bates	90	18	08. 34	270	06	18. 84	4. 3853254
Highland	211	41	41. 49	31	44	22. 96	4. 0211111
Walrod	285	49	02. 01	105	53	36. 45	3. 9898545
Peterson	311	39	50. 39	131	45	26. 57	4. 1886157
Quaker Hill	341	46	17. 09	161	51	00. 88	4. 4950339

PETERSON, CHAUTAUQUA COUNTY, N. Y.

In Carroll, about 3½ miles east of Frewsburg, on a bare hill on farm of Frank Peterson. View cut off to east by higher ridges.

Station mark: A sandstone post 36 by 6 by 6 inches set 32 inches in the ground, in center of top of which is a bronze triangulation tablet.

[Latitude 42° 02′ 48.23″. Longitude 79° 05′ 25.58″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Quaker	5	15	07. 39	185	14	15. 61	4. 2902612
Nelson	49	58	03. 48	229	51	48. 101	4. 2272878
Busti	74	38	04. 93	254	30	43. 27	4. 1970889
Meas	131	45	26. 57	311	39	50. 39	4. 1886157

BULL, WARREN COUNTY, PA.

In the southwest part of Sugar Grove Township, on a small knob of conglomerate rock on land owned by Warren Bull. An excellent view in every direction.

Station mark: A bronze triangulation tablet cemented in solid rock.

[Latitude 41° 55′ 34.76″. Longitude 79° 23′ 36.59″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Nelson	258	07	32.15	78	13	19.67	4.0877421
Yankee Bush	291	38	56.82	111	46	40.20	4.2359605
Crippen	335	03	06.01	155	05	41.12	4.1042866

CLARENDON, WARREN COUNTY, PA.

On a brushy and timbered hill about 3 miles west of Clarendon and 1 mile north of J. E. Boyd's house on Tionesta Creek, about 40 rods east of road going over the hill.

Station mark: A marble post 36 by 6 by 6 inches set 30 inches in the ground, in top of which is cemented a bronze triangulation tablet.

[Latitude 41° 47′ 04.13″. Longitude 79° 09′ 37.69″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Wilcox	90	33	56.69	270	30	24.03	3.8674586
Yankee Bush	161	38	51.48	341	37	21.45	3.9951024
Quaker Hill	202	32	50.55	22	34	47.05	4.0214009

CRIPPEN, WARREN COUNTY, PA.

In Brokenstraw Township, about 2 miles south of Youngsville, on a rocky timbered knob on land owned by A. L. Crippen. The view is good to north, but cut off to the southwest and south. Instrument elevated 34 feet on trunk of chestnut tree, around which is built a tower, which is fastened to the solid rock by four iron ring bolts.

Station mark: A bronze triangulation tablet cemented in solid rock.

Reference marks: Center of chestnut tree used for observing support and center of tower is distant 10 feet, azimuth 103° 43′.

[Latitude 41° 49′ 21.05″. Longitude 79° 19′ 34.22″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Bull	155	05	41.12	335	03	06.01	4.1042866
Nelson	205	15	30.15	25	18	42.17	4.1910446
Yankee Bush	244	06	05.15	64	11	13.06	4.0730680
Wilcox	302	57	13.28	123	00	18.19	3.8827312

NELSON, WARREN COUNTY, PA.

In Farmington, about 1 mile south of Lander post-office, in a cleared field on land owned by John T. Nelson.

Station mark: A marble post 36 by 6 by 6 inches set 34 inches in the ground, in the center of top of which is cemented a bronze triangulation tablet.

[Latitude 41° 56′ 56.06″. Longitude 79° 14′ 46.60″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Crippen	25	18	42.17	205	15	30.15	4.1910448
Bull	78	13	19.67	258	07	32.15	4.0877421
Busti	161	13	42.13	341	12	36.14	3.8485040
Meas	183	41	56.66	3	42	36.51	4.3260087
Peterson	229	51	48.10	49	58	03.48	4.2272878
Quaker	307	29	07.07	127	34	30.08	4.1477939
Yankee Bush	335	41	09.25	155	43	05.42	3.9885983

QUAKER HILL, WARREN COUNTY, PA.

In Glade, about 4 miles northeast of Warren, on a prominent bare hill on land owned by W. D. Ward.

Station mark: A marble post 36 by 6 by 6 inches, set 34 inches in the ground, in top of which is cemented a bronze triangulation tablet.

[Latitude 41° 52′ 18.57″. Longitude 79° 06′ 43.02″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Clarendon	22	34	47.05	202	32	50.55	4.0214009
Yankee Bush	87	29	21.33	267	25	54.64	3.8542143
Nelson	127	34	30.08	307	29	07.07	4.1477939
Meas	161	51	00.88	341	46	17.09	4.4950339
Peterson	185	14	15.61	5	15	07.39	4.2902612

WILCOX, WARREN COUNTY, PA.

On a brushy and timbered hill about 7 miles southwest of Warren and 2 miles east of Allegheny River, on land owned by Earl Wilcox.

Station mark: A bronze triangulation tablet cemented in solid rock.

Reference marks: Four iron ringbolts fastening signal to rock and distant about 6 feet from center of station.

[Latitude 41° 47′ 06.37″. Longitude 79° 14′ 56.83″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Crippen	123	00	18.19	302	57	13.28	3.8827312
Yankee Bush	204	30	14.43	24	32	17.23	4.0102466
Clarendon	270	30	24.03	90	33	56.69	3.8827312

YANKEE BUSH, WARREN COUNTY, PA.

In Conewango Township, about 3½ miles northwest of Warren, on roadside close to cemetery fence.

Station mark: A marble post 36 by 6 by 6 inches, set 28 inches in the ground, in top of which is cemented a bronze triangulation tablet.

[Latitude 41° 52′ 08.30″. Longitude 79° 11′ 52.69″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Wilcox	24	32	17.23	204	30	14.43	4.0102466
Crippen	64	11	13.05	244	06	05.15	4.0730580
Bull	111	46	40.20	291	38	56.82	4.2359605
Nelson	155	43	05.42	335	41	09.25	3.9885963
Quaker Hill	267	25	54.64	87	29	21.33	3.8542143
Clarendon	341	37	21.45	161	38	51.48	3.9951024

PENNSYLVANIA.

PRIMARY TRAVERSE.

DAUPHIN, LEBANON, AND YORK COUNTIES.

MIDDLETOWN QUADRANGLE.

The following geographic positions were determined by C. B. Kendall, field assistant, in October, 1905. The line begins at Rutherford station on the Philadelphia and Reading Railway, in Dauphin County, and runs easterly along highways via Hummelstown, Hockersville, and Bachmanville to Colebrook, in the southwest corner of Lebanon County, thence southerly via Milton Grove and Florin to Columbia, thence southwesterly via Wrightsville and Hellam to York.

Geographic positions along highways.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Rutherford station, 0.75 mile east of, center of north track under overhead road crossing	40	15	47.3	76	46	41.7
Rutherford station, 2.5 miles east of, 800 feet west of brick store, three corners, 35 feet west to telephone pole, 50 feet southeast to corner of yard fence	40	15	46.0	76	44	56.9
Hummelstown, 1.25 miles west of, T road to north, 40 feet northwest to corner of board fence, 40 feet southeast to telephone pole	40	15	42.1	76	43	45.6
Hummelstown, center of car track at center of intersection of Main and Hanover streets, 70 feet southeast to northwest corner of brick house, 70 feet northeast to southwest corner of stone house	40	15	55.3	76	42	28.9
Hummelstown, 1 mile east of, T road to south, 15 feet south to car track, 30 feet southeast to corner of fence	40	16	01.6	76	41	09.8
Hockersville, four corners, 30 feet southwest to northeast corner of stone blacksmith shop, 60 feet northwest to center of trolley track	40	16	23.1	76	39	22.2
Hockersville, four corners, 0.75 mile southeast of, 150 feet northwest of Fishbarn Church, 30 feet northeast to corner of cemetery fence, 40 feet southeast to locust tree	40	15	55.4	76	38	40.7
Vian, in east face of southeast corner of stone blacksmith shop, at forks of road, aluminum tablet stamped "Prim. Trav. Sta. No. 1, 1905"	40	15	20.7	76	37	56.4
Vian, 0.25 mile southeast of, three corners at rock schoolhouse	40	15	08.4	76	37	43.9
Bachmanville, four corners, 1.25 miles southwest of, 30 feet southeast to corner of fence, 30 feet northwest to corner of fence and signboard	40	14	22.8	76	36	41.3
Bachmanville, four corners, 30 feet north to corner of fence and signboard, 40 feet east to corner of iron fence	40	14	34.8	76	35	44.0
Bachmanville, 0.6 mile southeast of, crossing of Dauphin-Lebanon county line	40	14	15.7	76	35	06.5

Geographic positions along highways—Continued.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Lawn, 1 mile north of, four corners at yellow schoolhouse, 30 feet northeast to corner of fence, 50 feet southeast to northwest corner of schoolhouse	40	14	37.4	76	33	50.4
Colebrook station, 1.5 miles northwest of, forks of road, 40 feet northwest to signpost, 20 feet south to rail fence	40	14	46.3	76	32	15.5
Colebrook station, 0.5 mile northwest of, forks of road at schoolhouse, 40 feet south to signpost, 50 feet southeast to stone gatepost	40	14	46.6	76	31	06.6
Colebrook station, 750 feet north of, opposite "The Mansion," in west wall at northwest corner of stone tenant house of Monroe Shupp, aluminum tablet stamped "Prim. Trav. Sta. No. 2, 1905"	40	14	25.3	76	30	45.6
Colebrook station, 1.25 miles southeast of, T road west, 25 feet southwest to signpost	40	13	19.7	76	30	18.8
Colebrook station, 1.5 miles southeast of, stone post on Lebanon-Lancaster county line	40	13	00.2	76	30	19.6
County-line post, 1.12 miles southwest of, forks of road, 200 feet south of brick schoolhouse, 10 feet west to rail fence, 25 feet east to rail fence.	40	12	08.4	76	30	56.8
Brandt (Aaron) residence, forks of road 200 feet west of, 25 feet west to forked cherry tree, 20 feet south to rail fence	40	11	10.1	76	31	08.3
Milton Grove Cemetery, 1 mile north of, four corners, 30 feet northeast to corner of yard fence and signboard, 40 feet southeast to red gate	40	10	51.4	76	32	02.4
Milton Grove Cemetery, forks of road, 50 feet northwest to cemetery gate, 5 feet east to rail fence	40	10	04.6	76	32	11.8
Milton Grove, four corners, 30 feet southwest to corner of stone wall, 40 feet west to corner of stone wall	40	09	45.3	76	31	56.7
Milton Grove, 1 mile southeast of, four corners, 35 feet southeast to locust tree and signboard, 30 feet northwest to sassafras tree	40	09	05.0	76	31	42.0
Milton Grove, 2 miles south of, 200 feet west of schoolhouse, T road south, 20 feet south to signpost, 50 feet east to guy-wire pole	40	08	18.9	76	31	53.4
Florin, 0.75 mile northwest of, T road east, 25 feet southeast to corner of wire fence, 30 feet northeast to two locust trees	40	07	25.1	76	31	34.3
Florin, intersection of streets at Florin Hotel, 20 feet northwest to southeast corner of watering trough, 40 feet northeast to locust tree.	40	06	54.8	76	31	27.6
Florin Hotel, in south wall at southeast corner of brick foundation to porch, aluminum tablet stamped "Prim. Trav. Sta. No. 3, 1905"	40	06	54.9	76	31	28.2
Florin, 1.75 miles southeast of, four corners at schoolhouse, 25 feet east to telephone pole, 30 feet northwest to rail fence	40	05	29.7	76	31	13.0
Florin, 2.75 miles southeast of, roads west and north, 30 feet east to signpost, 20 feet north to stone wall	40	04	46.4	76	30	44.9
Big Chiquesalunga Creek, center of covered bridge over, Rapho-East Hempfield township line	40	04	08.4	76	30	00.6
Kinderhook, four corners, 35 feet west to corner of shop, 40 feet southeast to corner of store	40	03	11.0	76	29	56.6
Columbia, intersection of Seventh and Chestnut streets	40	02	16.7	76	29	56.8
Columbia, Northern Central Rwy. bridge over Susquehanna River, in capstone at southeast corner of east-shore abutment, aluminum tablet stamped "Prim. Trav. Sta. No. 4, 1905"	40	01	54.5	76	30	35.6
Wrightsville, three corners at small triangular grass plot, street to north, 40 feet north to two old cannons, 10 feet south to center of trolley track	40	01	29.9	76	32	03.2
Wrightsville, 0.75 mile southwest of, T road north at old blacksmith shop, 35 feet northwest to signboard, 15 feet south to trolley track	40	01	17.8	76	32	57.4
Wrightsville, 1.75 miles southwest of, T road north, 10 feet south to trolley track, 30 feet northwest to corner of fence	40	01	04.2	76	33	59.0
Hellam, Evangelical Lutheran Church, 1.5 miles northeast of, four corners, 15 feet south to trolley track, 25 feet northeast to street car waiting room	40	00	45.6	76	34	58.1
Hellam, Evangelical Lutheran Church, 0.6 mile northeast of, four corners, 25 feet northeast to corner of yard fence and signboard, 15 feet south to trolley track	40	00	29.8	76	35	48.4
Hellam, Evangelical Lutheran Church, in north wall of stone foundation and east of entrance to, aluminum tablet stamped "Prim. Trav. Sta. 5, 1905"	40	00	14.8	76	36	26.8
Stony Brook station, 0.8 mile northeast of, T road north, 25 feet northwest to corner of trolley station, 10 feet south to trolley track	39	59	41.6	76	27	59.2
Stony Brook station, center of Pennsylvania R. R. and Pike road crossing	39	59	13.2	76	38	40.3

Geographic positions along Pennsylvania Railroad, Stony Brook to York.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Heistand station, center of Pennsylvania R. R. track and under overhead road crossing	39	58	59.8	76	39	53.5
Heistand station, 0.8 mile southwest of, center of track at road crossing	39	58	48.2	76	40	57.4
York, east edge of, center of track at road crossing	39	58	32.1	76	42	25.6
York, Duke-street crossing, between north and south main tracks, 60 feet southeast to northwest corner of freight station, 65 feet southwest to northeast corner of passenger station	39	58	02.7	76	43	41.9
York, south meridian mark, in Pennsylvania Park. Station mark: A sandstone post 40 by 6 by 6 inches, having a bronze tablet cemented in its top, set 36 inches in ground, 430 feet east of center of Water street and 57 feet north of center of Fulton street	39	57	20.1	76	43	36.8

BERKS AND LANCASTER COUNTIES.

NEW HOLLAND QUADRANGLE.

The following geographic positions were determined in 1905 by primary traverse run by C. B. Kendall, field assistant. The line starts at Pequea, in Salisbury Township, Lancaster County, and runs westerly via highways nearly to Lancaster, thence northerly to Durlach, in Clay Township, thence easterly via Adamstown to Alleghenyville in Berks County.

Geographic positions along highways.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Pequea, Unity Evangelical Church, road corners	40	02	01.9	76	00	33.7
Millwood schoolhouse, road corners, 40 feet northwest to oak in school yard, 12 feet southeast to telephone pole	40	01	04.9	76	01	05.9
Buyerstown, four corners, 80 feet southeast to corner stone to blacksmith shop, 25 feet northwest to signpost "Gap 2.25 mi."	40	00	41.4	76	02	48.4
Vintage post-office, four corners, 50 feet north to corner of porch, 50 feet southwest to corner of dwelling, 120 feet south to Pennsylvania R. R	40	00	02.5	76	04	48.6
Tollgate, 150 feet east of, four corners, 25 feet northeast to corner of yard fence, 40 feet southwest to corner of school-yard fence	40	00	17.3	76	06	19.9
Paradise, road corners at Odd Fellows' Hall, 70 feet southeast to corner of hall, 30 feet southwest to corner of front yard	40	00	32.1	76	07	31.0
Paradise post-office, 400 feet west of, at southeast corner of A. R. Hersey's store, in south face of stonewall, aluminum tablet stamped "Prim. Trav. Sta. No. 8, 1905"	40	00	35.2	76	07	45.0
Sandersburg, four corners, 40 feet northeast to corner of yard fence, 25 feet south to maple at brick store	40	00	53.6	76	09	19.5
Sandersburg, 1 mile west of, four corners, 20 feet north to telephone pole, 10 feet south to trolley line	40	01	07.1	76	10	27.6
Pleasant View schoolhouse, 1 mile east of, four corners, 20 feet northeast to signpost, 45 feet west to locust tree	40	01	06.4	76	12	06.2
Pleasant View schoolhouse, 75 feet west of, on north side of east-west road, in face of large limestone bowlder, aluminum tablet stamped "Prim. Trav. Sta. No. 9, 1905"	40	00	46.6	76	13	21.1
Mill Creek, 0.5 mile southeast of, four corners, 20 feet southwest to corner of rail-and-wire fence, 40 feet northwest to corner of rail-and-wire fence	40	01	11.6	76	14	18.9
Fertility, 0.5 mile northwest of, three corners, 35 feet south to telephone pole, 50 feet northeast to white gate	40	01	58.9	76	14	44.8
Lancaster and Bird-in-Hand pike, road corners, 35 feet southeast to corner of fence, 35 feet southwest to corner of fence	40	02	24.2	76	14	12.2
Four corners, 35 feet northeast to corner of fence and 1 milepost, 12 feet northwest to corner of rail fence	40	02	58.1	76	13	39.6
Four corners, 25 feet north to corner of fence and sign, 35 feet northeast to corner of wire fence	40	03	23.3	76	12	55.3
Mechanicsburg, 2 miles southwest of, three corners, 125 feet north to corner of fence and sign, 15 feet east to corner of wire and rail fence.	40	04	03 4	76	13	23.5
New Holland pike, four corners, center of trolley track and north-south road	40	04	54.0	76	14	04.1

Geographic positions along highways—Continued.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Bushon's mill, 0.5 mile south of, four corners, 25 feet southeast to maple, 15 feet southwest to signpost	40	05	49.4	76	14	18.5
Oregon, forks of road at east end of, 12 feet north to telephone pole, 40 feet southwest to front-yard fence	40	06	55.8	76	14	34.9
West Earl, four corners, 20 feet northwest to signpost	40	07	51.6	76	13	03.1
West Earl Inn, southwest corner of, west fence, bronze tablet stamped "Prim. Trav. Sta. No. 10, 1905, Elev. 300 feet"	40	07	52.3	76	13	03.0
West Earl, 1.25 miles northwest of, road corners at yellow house, 30 feet southwest to corner of fence and milepost, 15 feet northwest to corner of yard fence	40	08	46.0	76	13	51.6
Rothville, 0.25 mile northeast of, forks of road, 15 feet northwest to signpost, 15 feet south to corner of small white crib	40	09	19.3	76	14	19.0
Millway station, 700 feet north of, in stone doorsill of front of Brubaker's mill, bronze tablet stamped "Prim. Trav. Sta. No. 11, 1905, Eleven 316 ft."	40	09	46.8	76	14	10.9
Millway station, 1.25 miles northeast of, four corners, 10 feet east to corner of rail fence, 90 feet west to signboard, 35 feet south to stump	40	10	34.4	76	13	30.8
Durlach, 3 miles south of, four corners, 15 feet northeast to corner of front-yard fence, 15 feet west to corner of front-yard fence	40	11	18.6	76	13	34.2
Durlach, 2.25 miles south of, forks of road	40	11	58.4	76	13	10.0
Durlach, 0.75 mile south of, three corners, 20 feet west to signpost, 45 feet north to front-yard gate	40	13	18.0	76	13	22.0
Durlach, four corners, 45 feet west to large willow, 70 feet northeast to southwest corner of brick store	40	13	53.2	76	13	49.0
Durlach, 0.5 mile north of, road corners at, Mount Airy Hotel, 50 feet to bench mark	40	14	20.2	76	13	43.2
Durlach, 0.5 mile north of, in south wall at southeast corner of Mount Airy Hotel, aluminum tablet stamped "Prim. Trav. Sta. No. 12, 1905"	40	14	20.4	76	13	43.8
Mount Airy Hotel, 0.75 mile east of, 15 feet northeast to corner fence painted "U. S. 536"	40	14	27.0	76	12	53.2
Schoeneck, 1 mile west of, four corners, 25 feet northeast to signpost, 30 feet southwest to post painted "460"	40	14	39.5	76	11	38.3
Schoeneck, five corners, 40 feet southeast to northwest corner of hotel, 20 feet northwest to corner of fence	40	14	29.9	76	10	33.5
Schoeneck, 0.75 mile southeast of, three corners, 25 feet northwest to signpost, 12 feet east to tree on fence line	40	14	17.9	76	09	44.4
Denver, 1 mile north of, 0.25 mile west of Philadelphia and Reading Rwy., four corners, 20 feet northeast to post painted "U. S. 461," 157 feet to bench mark	40	14	37.9	76	07	54.0
Denver, 1 mile north of, in east wall at southeast corner of small stone residence of Mrs. Rachael Walter, aluminum tablet stamped "Prim. Trav. Sta. No. 13, 1905"	40	14	39.4	76	07	53.3
Adamstown, 2.5 miles west of, four corners, 25 feet north to signpost, 40 feet northeast to corner of fence	40	14	41.4	76	06	16.3
Adamstown, 1.25 miles west of, three corners, 30 feet northwest to signboard	40	14	35.7	76	05	01.5
Adamstown, 1.25 miles east of, center of Conestoga Traction Co.'s track, at forks of road, 20 feet north to telephone pole painted "U. S. 489"	40	14	28.9	76	03	39.7
Lancaster-Berks county line stone monument at crossing of Reading-Lancaster pike	40	14	53.4	76	02	44.2
Alleghenyville, 1.75 miles northwest of, three corners, 100 feet northwest of schoolhouse, 10 feet northeast to corner of rail fence, 35 feet southeast to corner of rail fence	40	14	49.0	76	00	48.1
Alleghenyville, 1 mile northwest of, four corners, at Eight Mile House, 60 feet southeast to windmill, 60 feet northeast to front entrance of hotel	40	14	41.4	75	59	55.7
Alleghenyville, northwest corner of stone church	40	14	03.9	75	59	20.6

TENNESSEE.

PRIMARY TRAVERSE.

CANNON AND RUTHERFORD COUNTIES.

WOODBURY QUADRANGLE.

The following geographic positions on the United States standard datum were determined by a line of primary traverse run by C. B. Kendall, field assistant, in June, 1906. Starting at Liberty triangulation station of the Coast and Geodetic Survey, the line follows the borders of the quadrangle and is tied to Short Mountain triangulation station of the same Survey.

Magnetic declination, north border, 2° 29′ east; east border, 2° 2′ east; south border, 2° 52′ east; west border, 2° 35′ east.

Geographic positions along highways.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Liberty triangulation station, pole erected by citizens of town of Liberty to be observed for position of their town. It is N. 70° W., true bearing, and 275 poles from center of town and 200 feet above it	36	00	34.02	85	58	36.80
Liberty, 1.25 miles south of, three corners at schoolhouse, 40 feet northeast to sycamore on bank of creek, 25 feet southeast to telephone pole	35	59	35.1	85	59	01.0
Three corners, 1,000 feet south of store, T road southeast up hollow, at sycamore tree	35	58	29.0	85	59	05.9
Hancock's store, three corners, T road to west up Sycamore Creek, at forks of road, roads north and east	35	57	12.3	85	59	40.9
Gassaway, center of Clear Fork Creek at forks of road	35	56	25.1	85	59	45.3
Clear Fork and Wyandotte creeks, junction of, at forks of road up each	35	55	17.5	85	59	21.9
Four corners, second-class northeast and southwest crossroads, southwest road follows up Clear Fork, 50 feet south to large rock at point of ridge	35	54	41.8	85	58	24.2
Second-class road to west, 10 feet east to oak tree	35	53	22.5	85	57	28.4
Second-class road, 20 feet east to oak, 20 feet north to old oak stump	35	52	43.5	85	57	12.7
Short Mountain triangulation station, on highest group of Short Mountains, 2 miles northwest of Short Mountain post-office, which is kept at Comer's store; road passes Blair's and John Herringer's; signal is on land of Mr. Dougald. Station mark: A bottle filled with ashes, the center of the neck accurately under station; above bottle is a stone 8 inches square and 3 feet long, rising 3 inches above surface, with intersecting grooves north and south and east and west marking point	35	52	11.5	85	58	23.2
Forks of road west and northwest, 40 feet north to large oak stump, 40 feet south to large sycamore stump	35	52	33.4	85	56	52.3
Comer's store, forks of road 600 feet south of, roads southeast and south, 90 feet east to beech tree	35	51	13.4	85	56	32.9
Wood's store, three corners, T road west, 35 feet east to store door, 40 feet southwest to large oak	35	50	43.7	85	56	45.2
Forks to east, 40 feet west to door of log church	35	49	59.2	85	56	48.0
Four corners, 10 feet southeast to oak tree and signboard "Manchester 26 miles," 40 feet northeast to two mail boxes	35	49	03.3	85	56	56.0
Four corners, 15 feet east to oak, 30 feet southwest to two oaks	35	48	11.2	85	57	18.0
Forks of road northeast, 30 feet southwest to oak, 40 feet south to oak	35	47	13.5	85	57	45.1
Second-class road forks to northeast, oak tree	35	46	19.9	85	58	01.0
Burns's store, three corners 0.25 mile west of, 20 feet southwest to large oak	35	45	55.8	85	58	37.0
Davenport's store, 1,500 feet northwest of, 7 miles southeast to Woodbury, in east wall northeast corner of R. L. Spidell's brick spring house, on south edge of old stage road from Woodbury to Minnville, aluminum tablet stamped "Prim. Trav. Sta. No. 5, 1906"	35	46	38.3	85	59	11.9
Forks of road at sawmill	35	46	25.5	85	59	42.8
Iconium Church, three corners ½ mile east of, T road north near corner of clearing, 40 feet southwest to oak, 90 feet north to oak	35	46	29.5	86	00	49.1
Public roads, oak tree in southwest corner	35	46	05.1	86	01	56.5
Three corners, road to west at bend of main road to south, 15 feet southeast to corner of fence, 20 feet north to fence	35	45	36.1	86	02	42.7
Four corners, intersection of Woodbury-Manchester and Short Mountain-Pettys Gap roads, 40 feet northeast to oak, 90 feet southwest to oak, 300 feet northeast to Quickstep schoolhouse	35	45	04.1	86	03	19.6

Geographic positions along highways—Continued.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Four corners, 0.5 mile east of Old Pettys post-office, 80 feet northeast to oak tree, 40 feet north to oak	35	44	45.3	86	03	35.0
Second-class road at small graveyard, 40 feet north to gate, 20 feet south to gate	35	45	17.9	86	04	58.5
Bent, three corners, 1.75 miles southeast of, T road south to Jamison's brandy distillery, 20 feet northwest to oak tree, 100 feet south to bridge	35	45	21.0	86	06	19.1
Forks of road, 100 feet northwest of barn and 300 feet southeast of Horse Spring Fork, roads northwest down and southeast up, 40 feet southeast to barnyard gate, 60 feet northeast to locust tree	35	45	39.0	86	06	53.3
Burt Carsons Fork, center of, at ford 0.25 mile southwest of	35	45	58.1	86	07	53.9
West side of Woodbury-Hollow Springs road, 80 feet west of center of Carsons Fork, at junction with public road leading southwest over ridge to Bradyville and 250 feet north of new store on Bradyville road, in limestone rock, aluminum tablet stamped "Prim. Trav. Sta. No. 6, 1906"	35	44	45.0	86	07	44.8
Second-class T road to northeast down hollow 5 feet southwest to stone fence, 30 feet north to bench of sycamore sprouts	35	44	25.3	86	09	00.9
Readyville, junction of Murfreesboro-Hollow Springs pike and T road to east, 40 feet southeast to corner of store porch, 35 feet northeast to store porch	35	44	22.6	86	09	56.7
Three corners, 1.12 miles west of Readyville, second-class T road to north, 25 feet northwest to gate, 10 feet south to rail fence	35	44	46.5	86	10	49.3
Murfreesboro-Hollow Springs pike, 50 feet north of center of, in new corner of junction of pike with road north down Cripple Creek to Bradyville, 2,000 feet west of church, in limestone bowlder, aluminum tablet stamped "Prim. Trav. Sta. No. 7, 1906"	35	44	50.4	86	11	27.7
Forks of road uphill to northeast, 60 feet north to locust tree	35	45	54.6	86	11	31.2
Three corners, public T road to north, 10 feet south to B. M. Beeton's mail box, 30 feet northeast to peach tree	35	46	51.7	86	12	23.1
Three corners, 0.75 mile south of pike, second-class T road northwest, 40 feet south to large oak, 30 feet northwest to cedar	35	48	21.1	86	12	17.4
Readyville post-office, forks of road ½ mile north of	35	49	44.9	86	10	44.8
Readyville, forks 1 mile north of, road north and northwest, 15 feet north to stone walk, 40 feet east to wire fence	35	50	04.7	86	11	23.8
Readyville, four corners 2 miles north of, crossroads, 10 feet southwest to three cedars, 50 feet east to cedar	35	50	48.3	86	11	11.1
Auburn pike, 60 feet northeast to large oak, 30 feet southwest to rail fence	35	51	48.5	86	11	31.0
Murfreesboro-Auburn pike, in north edge of, at three corners, 500 feet east of Antioch Church, T road south to Readyville and 3.3 miles north of, aluminum tablet stamped "Prim. Trav. Sta. No. 1, 1906"	35	51	48.8	86	11	31.4
Four corners, second-class crossroads, 10 feet southwest to corner of fence, 40 feet northeast to hickory tree	35	52	26.6	86	12	10.4
Forks of road, public roads south and southwest, 600 feet southwest of church, 30 feet west to cedar	35	53	29.3	86	12	01.5
Milton, crossroads, 1.6 miles south of, center of rock ledge, 40 feet east to elm, 50 feet west to mail box	35	54	50.4	86	11	36.0
Milton, Presbyterian Church, junction of Milton-Murfreesboro pike and Readyville road, 25 feet southwest to corner of wire fence, 35 feet southeast to corner of churchyard fence	35	55	46.4	86	10	56.1
Three corners, T road west, 20 feet southwest to small bridge, 30 feet east to gate, 10 feet northwest to J. H. Paty's mail box	35	56	42.0	86	10	42.7
Three corners, T road northwest, 10 feet north to corner of rock fence, 12 feet west to mail box No. 74	35	58	01.6	86	10	28.0
Ewingsville schoolhouse, 3.1 miles north of Milton, on Milton-Statesville road, limestone rock, being northwest corner of Woodbury quadrangle, aluminum tablet stamped "Prim. Trav. Sta. No. 2, 1906"	35	58	28.7	86	10	24.5
Forks of roads northwest to northeast, up small stream, 50 feet north to poplar tree, 50 feet east to center of stream	35	58	27.3	86	09	09.6
Forks of roads, east down Kennedy Creek and uphill to Auburn, 10 feet south to rock fence	35	58	03.3	86	08	25.2
Three corners, T road to south, 25 feet southwest to corner of rail fence, 25 feet southeast to H. W. Preston's mail box	35	58	13.3	86	05	50.2
Junction Kennedy Creek road and Murfreesboro pike and Herican road, 1.5 miles east of Auburn and about 300 feet north of Wilson-Cannon county line, 30 feet south of center of pike, in limestone ledge, aluminum tablet stamped "Prim. Trav. Sta. No. 3, 1906"	35	57	55.9	86	04	32.4
Forks at west end of old bridge site, road northeast, limestone bowlder, 40 feet southwest to gate at store fence, 80 feet north to corner of barn, 125 feet east to center Sanders Fork	35	58	35.0	86	04	14.3
Prosperity, steeple of church	35	58	47.0	86	03	27.1
Three corners at east end of old bridge site across Sanders Fork, T road to north, 35 feet southwest to tree, 25 feet north to stone fence.	35	59	19.1	86	02	21.5
T road southeast, 40 feet southeast to gate	36	00	08.0	86	01	16.4
Liberty, forks of pike 2 miles northwest of, 50 feet northwest to corner of store, 40 feet south to corner of blacksmith shop	36	00	41.1	86	00	00.7
Liberty, west edge of, 80 feet north of northwest corner of Salem Baptist Church, in limestone ledge, aluminum tablet stamped "Prim. Trav. Sta. No. 4, 1906"	36	00	13.1	85	58	27.6

VIRGINIA.

TRIANGULATION STATIONS.

FLOYD AND PATRICK COUNTIES.

FLOYD AND STUART QUADRANGLES.

In the fall of 1905 W. H. Lovell, topographer, extended triangulation control over the Floyd quadrangle and the northern portion of the Stuart quadrangle. Seven new stations, based on Buffalo and Bull of the Coast and Geodetic Survey, were occupied.

BUFFALO, FLOYD COUNTY.

On a high narrow ridge cleared on all sides, about 15 miles by road southwest of Floyd. Best reached from J. A. Alderman's house by good path. A station of the Coast Survey.

Station mark: A bronze tablet in solid ledge.

[Latitude 36° 47′ 46.15″, longitude 80° 28′ 39.05″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Stocker	231	42	41	51	48	39	4.27487
Haycock	248	20	16	68	27	47	4.30184
Bull	296	49	47	116	58	51	4.40296
Hylton	305	38	00	125	43	07	4.19545
Turner	321	10	54	141	14	57	4.20722

HAYCOCK, FLOYD COUNTY.

On a high partly cleared hill about 5 miles southeast of Floyd and 0.75 mile from Haycock post-office, on what is known as the Lee farm. Wagon can be driven to signal.

Station mark: A bronze tablet set in sandstone rock.

[Latitude 36° 51′ 45.4″, longitude 80° 16′ 07.2″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Hylton	19	40	50	199	38	30	4.24422
Buffalo	68	27	47	248	20	16	4.30184
Stocker	138	09	26	318	08	23	3.75940
Bull	348	16	41	168	18	15	4.28360

STOCKER, FLOYD COUNTY.

On Stockers Knob, about 0.75 mile south of Floyd court-house, near Floyd-Stuart pike. Hill cleared except to west. Can drive to station.

Station mark: A drill hole in quartz rock.

[Latitude 36° 54′ 04.2″, longitude 80° 18′ 42.1″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Hylton	5	40	50	185	40	00	4.32029
Buffalo	51	48	39	231	42	41	4.27487
Haycock	318	08	23	138	09	26	3.75940
Bull	341	27	12	161	30	19	4.38671

BULL, PATRICK COUNTY.

On the highest peak of a group of high wooded hills a few miles north of Stuart. Best reached by following the Stuart-Patrick Springs highway to a point 4 miles from Stuart and 1 mile east of Mr. Orr's house. A path leads up south spur to summit.

Station mark: A bronze tablet in rock set in ground.

[Latitude 36° 41′ 34.97″, longitude 80° 13′ 29.93″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Noel	24	11	46	204	10	22	3.93032
Carter	43	44	02	223	41	16	4.00004
Turner	84	55	08	264	50	08	4.09753
Hylton	103	12	04	283	08	08	4.00330
Buffalo	116	58	51	296	49	47	4.40298
Stocker	161	30	19	341	27	12	4.38671
Haycock	168	18	15	348	16	41	4.28360

CARTER, PATRICK COUNTY.

About 3 miles southwest of Stuart, on the summit of a ridge called Carters Mountain, on land of William Hayden. View intercepted by woods to west and northwest.

Station mark: A bronze tablet in sandstone rock.

[Latitude 36° 37′ 40.4″. Longitude 80° 18′ 18.2″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Hylton	163	02	00	343	00	50	3.99821
Bull	223	41	16	43	44	02	4.00004
Stuart	242	01	00	62	02	00	3.52906
Noel	278	58	00	98	59	00	3.53924

HYLTON, PATRICK COUNTY.

On a high, bare ridge about 250 feet east of the highway leading from Stuart to Cruise and within 0.12 mile of Cruise post-office, on land owned by A. A. Hylton, who lives a few hundred feet south of the station.

Station mark: A dead tree 60 feet high with a triangle of six nails driven in the side facing Buffalo.

[Latitude 36° 42′ 49.4″. Longitude 80° 20′ 05.4″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Turner	37	51	23	217	49	50	3.63573
Buffalo	125	43	07	305	38	00	4.19545
Stocker	185	40	00	5	40	50	4.32029
Haycock	199	38	30	19	40	50	4.24422
Bull	283	08	08	103	12	04	4.00330
Noel	327	49	10	147	51	42	4.07515
Carter	343	00	50	163	02	00	3.99821

NOEL, PATRICK COUNTY.

Three miles south of Stuart, in an open field 100 feet west of public road, on land of Mrs. Noel.

Station mark: A bronze tablet in rock at pile of stones.

[Latitude 36° 37′ 22.9″. Longitude 80° 15′ 50.5″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Carter	98	58	00	278	58	00	3.53924
Hylton	147	51	42	327	49	10	4.07515
Bull	204	10	22	24	11	46	3.93032

STUART METHODIST EPISCOPAL CHURCH SPIRE, PATRICK COUNTY.

Station mark: Center of spire.

[Latitude 36° 38′ 31.9″. Longitude 80° 16′ 08.0″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Carter	62	02	00	242	01	00	3.52906
Noel	348	29	00	168	29	00	3.33639

TURNER, PATRICK COUNTY.

About 4 miles southwest of Cruise post-office, on land of Rufus Turner, within 200 yards of road and house.

Station mark: Dead stump of tree 9 feet high having triangle of nails driven in west side.

[Latitude 36° 40′ 58.7″. Longitude 80° 21′ 52.1″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Buffalo	141	14	57	321	10	54	4.20722
Hylton	217	49	50	37	51	23	3.63573
Bull	264	50	08	84	55	08	4.09753

ALLEGHANY, BATH, BEDFORD, BOTETOURT, CRAIG, AND ROCKBRIDGE COUNTIES.

BUCHANAN AND FINCASTLE QUADRANGLES.

In the spring of 1906 Oscar Jones, topographer, located four new stations for the control of two 15-minute quadrangles. Positions are based on Bald Knob, Flat Top, and Potts, United States standard datum.

RICH PATCH, ALLEGHANY AND BOTETOURT COUNTIES.

(Not occupied.)

On a flat timbered summit of Rich Patch Mountain, 4 miles north of Oriskany, the nearest railroad station. May be reached by road from Oriskany to old Grace Furnace, thence by path which crosses mountain 2 miles southwest of station.

Station mark: A monument of stone 6 feet in diameter at the base and 5 feet high, piled around the base of an oak tree 12 inches in diameter in which is placed a signal.

[Latitude 37° 40′ 38.09″. Longitude 79° 58′ 14.37″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Sugar Loaf	274 53 54.9	95 04 01.6	4.387810
Flat Top	306 00 46.9	126 14 58.9	4.627556
Caldwell	4 23 39.2	184 23 06.1	4.239700

POTTS, ALLEGHANY AND CRAIG COUNTIES.

A station of the Geological Survey first established in 1885, on the Craig-Alleghany county line, on a rounded knob on Potts Mountain east of the Fincastle-Sweet Springs road, 12 miles by road and trail north of Newcastle. The old stage from Newcastle to Sweet Springs crosses the mountain 0.25 mile west of the station.

Station mark: The birch signal tree, around which is a mound of stone.

Reference marks: Two holes drilled in solid rock: No. 1, station bears N. 22° E magnetic, distant 12.1 feet; No. 2, station bears S. 42° W. magnetic, distant 7.7 feet.

[Latitude 37° 36′ 02.9″. Longitude 80° 08′ 45.0″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Bald Knob	215 39 03.8	35 49 53.1	4.647675
Sugar Loaf	260 46 54.7	81 03 25.9	4.605446
Flat top	288 12 03.4	108 32 37.9	4.719626
Caldwell	301 55 13.3	122 01 04.7	4.222150

BALD KNOB, BATH COUNTY.

Coast Survey station on Warm Springs Mountain, about 3 miles (air line) south of Healing Springs, 1,000 feet north of highest summit and 20 feet lower. Millboro depot and Covington, nearest railroad stations.

Station mark: (C. and G. S.; could not be found.)

Reference marks: One stone post bearing S. 87° E. true, distant 7 feet; one hole bearing S. 87° W. true, distant 7.28 feet; one hole bearing N. 8° W. true, distant 10.58 feet.

[Latitude 37° 55′ 32.58″. Longitude 79° 51′ 04.77″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Sugar Loaf	335	03	49.0	155	09	34.2	4.515084
Flat Top	335	40	48.5	155	50	39.8	4.760975
Potts	35	49	53.1	215	39	08.8	4.647675

CALDWELL, BOTETOURT COUNTY.

A point on the southwest end of Caldwell Mountain, about 7 miles west of Fincastle. Station may be reached from Fincastle by following the Newcastle road almost to the top of the mountain, turning to the left at an apple orchard on the summit. There is a road up the hollow to a point within 1 mile of the station. Good view.

Station mark: A bronze tablet cemented in solid rock.

Reference marks: Arrow cut in rock bearing N. 63½° E. magnetic, distant 6.75 feet; arrow cut in rock bearing N. 59½° W. magnetic, distant 2.68 feet.

[Latitude 37° 31′ 16.46″. Longitude 79° 59′ 08.55″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Potts	122	01	04.7	301	55	13.3	4.222150
Rich Patch	184	23	06.1	4	23	39.2	4.239700
Sugar Loaf	239	18	30.9	59	29	09.6	4.474849
Flat Top	282	04	03.3	102	18	45.8	4.561680

SUGAR LOAF, BOTETOURT COUNTY.

On the east end of Sugar Loaf Mountain, 12 miles north of Buchanan. Buchanan-Daggers Springs road up Purgatory Creek crosses divide 0.75 mile east of station. The top is cleared, giving a good view in all directions.

Station mark: A bronze tablet set in cement 18 inches below the surface, over which is built a mound of stone 6 feet in diameter at the base and 5 feet high.

Reference marks: A 1-inch hole drilled in solid rock bearing N. 65° W. magnetic, distant 12 feet; a 1-inch hole drilled in solid rock bearing N. 70° E. magnetic, distant 14.60 feet.

[Latitude 37° 39′ 29.27″. Longitude 79° 41′ 41.59″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Caldwell	59	29	09.6	239	18	30.9	4.474849
Potts	81	03	25.9	260	46	54.7	4.605446
Rich Patch	95	04	01.6	274	53	54.9	4.387810
Bald Knob	155	09	34.2	335	03	49.0	4.515084
Short Hill	254	24	25.2	74	28	18.3	3.987007
Flat Top	336	35	03.2	156	39	09.0	4.396856

FLAT TOP, BOTETOURT AND BEDFORD COUNTIES.

A station of the Coast Survey 10 miles northwest of Liberty, Bedford County. Rough wagon road within one-fourth mile of station.

Station mark: A bronze tablet cemented in stone bowlder, replacing Coast Survey bench mark, which had been removed.

[Latitude 37° 27′ 06.78″. Longitude 79° 34′ 58.40″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Caldwell	102	18	45.8	282	04	03.3	4.561680
Potts	108	32	37.9	288	12	03.4	4.719626
Rich Patch	126	14	58.9	306	00	46.9	4.627556
Bald Knob	155	50	39.8	335	40	48.5	4.760975
Sugar Loaf	156	39	09.0	336	35	03.2	4.396856
Short Hill	178	48	18.1	358	48	04.9	4.406521

SHORT HILL, ROCKBRIDGE COUNTY.

(Not occupied.)

On mountain known as Short Hill, about 5 miles northwest of Natural Bridge. A road crosses the ridge about 0.75 mile north of the station. There are two knolls near each other, the east one covered with timber, the west one bare. The station is on the west knoll. A good view can be had in all directions.

Station mark: A mound of stone 8 feet in diameter at the base and 6 feet high.

[Latitude 37° 40′ 53.72″. Longitude 79° 35′ 20.10″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Flat Top	358	48	04.9	178	48	18.1	4.406521
Sugar Loaf	74	28	18.3	254	24	25.2	3.987007

WEST VIRGINIA.

TRIANGULATION STATIONS.

BRAXTON, CALHOUN, CLAY, KANAWHA, ROANE, AND WIRT COUNTIES.

ARNOLDSBURG, FLATWOOD, LITTLE OTTER, MINNORA, SPENCER, AND WALTON QUADRANGLES.

Triangulation control was extended in 1904 by C. A. Clunet, field assistant, from stations Ruble, Staats, and Weed. Twenty-three new stations were located on the United States standard datum.

COON, BRAXTON COUNTY.

On a high peak at the head of Coon Creek, 2 miles northwest of Hoover post-office and 6 miles southwest of Sutton; timber is mostly cleared from top of knob. Land is owned by T. M. Dean, who lives at Hoover. A ridge road runs 300 yards south of signal.

Station mark: A sandstone post 36 by 8 by 8 inches, set 30 inches in the ground and having a stamped bronze triangulation tablet cemented in the top.

Reference mark: The chestnut oak signal tree, distant 17.5 feet, true azimuth 333°.

[Latitude 38° 36′ 53.36″. Longitude 80° 46′ 49.92″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Harrison	58 12 12.2	238 05 21.0	4.274113
Pilot	72 30 53.5	252 17 44.8	4.506895
Frame	....	....	4.133550
Mule	111 03 34.0	290 52 58.8	4.420506
Sugar	164 33 57.0	344 32 46.3	4.012311
High	240 48 59.0	60 56 47.0	4.316880
Green	....	....	4.140960

FRAME, BRAXTON COUNTY.

(Not occupied. Position unchecked.)

On a high, wooded peak 1 mile northeast of Servia post-office.

Station mark: A large chestnut tree having cleats nailed up trunk to top, which is cut out.

[Latitude 38° 37′ 40.3″. Longitude 81° 56′ 10.1″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Pilot	....	....	4.30581
Coon	....	....	4.13355

GIP, BRAXTON COUNTY.

(Not occupied. Position unchecked.)

On a high, partially wooded summit known locally as Rattlesnake Hill, 0.5 mile northeast of Gip post-office, on land of Mr. Miller, who lives at Gip.

Station mark: A stone post 24 by 8 by 8 inches, set 20 inches in the ground.

Reference marks: A large chestnut-oak tree (signal tree) 5 feet east of station.

[Latitude 38° 40′ 15.9″. Longitude 80° 58′ 55.9″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Weedy			4.17697
Mule			3.88757

GREEN, BRAXTON AND NICHOLAS COUNTIES.

(Not occupied. Position unchecked.)

On a high, wooded knob 5 miles southeast of Littlebirch post-office and 3 miles north of Skyles post-office, at the head of Carpenter Fork to the north and Mill Creek to the west, on the Braxton-Nicholas county line and 0.5 mile west of Webster County line. Station is 150 yards east of county road and 300 yards north of forks of road at top of hill at George Wynn's house.

Signal: A flag and target on top of red-oak tree 20 feet south of fence line, distant from station 22 feet.

Station mark: A sandstone post 36 by 8 by 8 inches, set 28 inches in the ground and having a bronze triangulation tablet cemented in the top.

[Latitude 38° 31′ 39.4″. Longitude 79° 40′ 01.7″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Coon			4.14095
High			4.33104

HIGH, BRAXTON COUNTY.

On a high knob, mostly cleared, 12 miles northeast of Sutton and 2 miles west of Caress post-office, in pasture on land of John Marple, who lives in hollow 0.5 mile northwest of station. Station is 3 feet north of east-west fence line, 100 yards north of forks of county road and same distance east of Methodist Church.

Station mark: A sandstone post 36 by 8 by 8 inches, set 30 inches in the ground and having a bronze triangulation tablet cemented in top.

[Latitude 38° 42′ 20.73″. Longitude 79° 34′ 20.41″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Green	22 41 40	....	4.33164
Coon	60 56 47	240 48 59	[illegible]
Sugar	89 35 10	269 26 10	4.31906

SUGAR, BRAXTON COUNTY.

At the head of Sugar Creek, on a high knob locally known as Sugar Knob, 4 miles northwest of Gassaway station, on the Coal and Coke Railway, on land of Mr. Dodery, east side of summit cleared and west side timbered.

Station mark: A stone post.

Reference marks: The tall, straight hickory tree on north-south fence line which divides the woods from cleared land, distant from station 14.6 feet, azimuth 175° 16′.

[Latitude 38° 42′ 14.94″. Longitude 79° 49′ 43.22″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Harrison	33 43 12.8	213 37 31.9	4.37735
Mule	88 47 22.3	268 37 57.3	[illegible]
High	269 26 10.0	89 35 10.0	4.31906
Coon	344 32 46.3	164 33 57.0	4.01231

DESERT, CALHOUN COUNTY.

On a high, cleared peak in pasture 2 mile south of Beech postoffice and 0.25 mile east of Roane County line, on land of Joseph Wagner, who lives on east slope of knob, locally known as Desert Peak.

Station mark: A sandstone post 36 by 7 by 7 inches, set 32 inches in the ground and having a bronze triangulation tablet cemented in top.

Signal: A tall chestnut-oak tree near top of hill.

[Latitude 38° 44′ 32.91″. Longitude 81° 09′ 59.88″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Craig	128 34 26.1	308 28 56.2	[illegible]
Rattlesnake	172 22 36.1	352 21 33.6	[illegible]
Millstone	232 24 31.0	52 28 01.0	[illegible]
Mule	297 44 21.2	117 48 14.5	[illegible]

MILLSTONE, CALHOUN COUNTY.

On a high, cleared knob 3.5 miles northeast of Arnoldsburg and 0.5 mile southwest of Millstone post-office, on land of Mr. Altizer, of Arnoldsburg.

Station mark: A stone post 36 by 7 by 7 inches, set 30 inches in the ground and having a bronze triangulation tablet cemented in the top.

[Latitude 38° 47′ 55.2″. Longitude 81° 04′ 24″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Desert	52 28 01	232 24 31	4.00968
Rattlesnake	138 09 47	318 05 14	4.19694
Kite			4.21711

MULE, CALHOUN COUNTY.

On a high, sharp peak, mostly cleared, 1.5 miles southeast of Minnora post-office, on land of Charles Knoth, who lives on south side of hill. Road almost to top. Locally known as Mule Knob.

Station mark: A stone post, 28 by 9 by 9 inches, set 26 inches in the ground and having a bronze tablet cemented in the top.

[Latitude 38° 41′ 59.01″. Longitude 81° 03′ 46.86″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Pilot	17 26 22.8	197 23 47.9	4.302253
Weedy	28 08 46.4	208 06 15.6	4.093060
Spencer	99 43 53.5	279 32 54.5	4.411902
Desert	117 48 14.5	297 44 21.2	4.007943
Craig	124 28 02.0	304 18 39.0	4.420269
Lukens	135 51 21.3	315 42 09.8	4.483672
Rattlesnake	153 21 33.5	333 16 37.3	4.404923
Sugar	268 37 57.3	88 47 22.3	4.339282
Coon	290 52 58.8	111 03 34.0	4.420508
Gip	294 18 06.0		3.887570
Harrison	335 53 09.5	155 56 52.5	4.326130

KITE, CALHOUN COUNTY.

On a high, cleared knob, 3 miles northeast of Grantsville and 0.25 mile southeast of Glenville road, on land belonging to Mrs. Maggie Spoon, who lives on south side of hill.

Station mark: A stone post, 36 by 8 by 8 inches, set 30 inches in the ground and having a bronze triangulation tablet cemented in the top.

[Latitude 38° 56′ 46.7″. Longitude 81° 03′ 11.3″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Millstone			4.21711
Rattlesnake			4.11750

LUKENS, CALHOUN-WIRT COUNTY LINE.

About 5 miles northwest of Richardson, on a high, partly cleared knob, on land owned by Mr. Quick and about 0.5 mile from house of Mr. Lukens. There are a few chestnut trees on the north side of the knob and pines on the south. There is also an old peach orchard on top.

Station mark: A blue freestone post, 36 by 8 by 8 inches, set 30 inches in the ground, in the center of top of which is cemented a bronze triangulation tablet.

[Latitude 38° 53′ 46.84″. Longitude 81° 18′ 27.05″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Craig	3	51	01.25	183	50	49.06	[illegible]
Poplar	18	05	57.27	198	04	02.62	[illegible]
Ball	55	26	09.26	235	22	13.84	[illegible]
Weed	[illegible]	40	15.91	277	32	54.51	[illegible]
Ruble	183	[illegible]	56.34	3	08	14.74	[illegible]
Rattlesnake	264	52	52.47	84	57	08.33	[illegible]
Mule	315	42	[illegible]	135	51	21.30	[illegible]

RATTLESNAKE, CALHOUN COUNTY.

On a high peak, mostly cleared of timber, at the head of Annamoriah Run, 0.5 mile west of Joker post-office, on land of Camden Somers, of Clarksburg, locally known as Rattlesnake Knob.

Station mark: A bronze tablet cemented in solid rock.

Reference marks: A tall lone pine tree 21.36 feet due west; [illegible] cut in solid rock 11.13 feet due south.

[Latitude 38° 54′ 15.16″. Longitude 81° 11′ 39.62.″]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Spencer	37	22	26.53	217	16	22.43	4.3637765
Craig	52	45	14.47	[illegible]	40	46.59	4.1117250
Lukens	84	57	08.33	[illegible]	52	52.47	3.9937419
Ruble	142	49	37.84	[illegible]	45	40.06	4.1777789
Kite							4.1175000
Millstone	318	05	14.00	138	[illegible]	47.00	4.1969400
Mule	333	16	37.30	153	21	[illegible]	4.4049230
Desert	352	21	33.60	172	22	[illegible]	4.2580300

HARRISON, CLAY COUNTY.

On a high, wooded peak 1 mile northwest of Harrison post-office and 1 mile east of Sand Fork, on the Brackerhoff tract of land. A wood road runs almost to signal tree from the south from the Clay-Sutton road on top of the hill 0.5 mile east of Sand Fork.

Signal: A flag in a large chestnut oak having cleats nailed up[illegible] platform in top of tree.

Station mark: A bronze triangulation tablet cemented in solid rock.

Reference marks: Chestnut-oak signal tree, distant 13.8 feet, azimuth 277° 56′.

[Latitude 38° 31′ 31.62″. Longitude 80° 57′ 49.48″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Pilot	90	52	03.7	270	45	46.5	4.166418
Mule	155	56	52.5	335	53	09.5	4.326130
Sugar	213	37	31.9	33	43	12.8	4.377235
Coon	238	05	21.0	58	12	12.2	4.274113

PILOT, CLAY COUNTY.

On a high knob which has been cleared of timber on top, 0.5 mile northwest of Valley Fork post-office, on land owned by Swann, Brown & Co. Road crosses gap 0.5 mile east of station.

Station mark: A stone post, 36 by 8 by 8 inches, set 30 inches in the ground and having a bronze triangulation tablet cemented in the top.

[Latitude 38° 31′ 38.40″. Longitude 81° 07′ 55.02.″]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Campbell	99	29	50.6	279	20	14.7	4.355820
Nichols	127	34	30.5	307	28	30.7	4.245792
Spencer	140	21	51.7	320	13	28.9	4.484208
Weedy	181	07	06.1	1	07	10.3	3.914430
Mule	197	23	47.9	17	26	22.8	4.302255
Frame	237	29	12.0				4.305810
Coon	252	17	44.8	72	30	53.5	4.506893
Harrison	270	45	46.5	90	52	03.7	4.166418

GUNSTOCK, KANAWHA COUNTY.

On a high, wood-topped peak, 2 miles south of Kettle post-office and 1 mile south of the Roane County line, on land belonging to M. A. Tuipin, who lives on the northeast side of the hill.

Station mark: A stone post, 36 by 8 by 8 inches, set 30 inches in the ground and having a bronze triangulation tablet cemented in the top.

[Latitude 38° 32′ 51.34″. Longitude 81° 29′ 58.31.″]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Countsville	198	16	58.0				4.235120
Spencer	210	30	57.8	30	36	21.2	4.391509
Nichols	244	47	27.6	64	55	13.1	4.300013
Campbell	261	21	08.9	81	25	17.7	3.989073

BALL, ROANE COUNTY.

About 5 miles northwest of Spencer and 1.5 miles southwest of Kyger, on a cleared ridge, near its north end, on land of Mr. Ball and about 0.75 mile nearly east of his house.

Station mark: A blue freestone post, 36 by 8 by 8 inches, set 30 inches in the ground, in the center of top of which is cemented a bronze triangulation tablet.

Reference mark: A dead snag used for signal, distant 4.3 feet, true azimuth 31° 49′.

[Latitude 38° 50′ 24.53″. Longitude 81° 24′ 42.21″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Staats	111	19	39.49	291	16	19.98	3.915424
Weed	137	08	05.22	317	04	39.56	4.064585
Lukens	235	22	13.84	55	26	09.26	4.040895
Craig	274	47	04.47	94	50	47.55	3.935010
Poplar	323	22	40.70	143	24	47.25	3.912219

CAMPBELL, ROANE COUNTY.

On a high bare knob 2 miles east of Dodd post-office, in pasture on land owned by W. C. Campbell, who lives on the west side of the hill.

Signal: A lone tree with limbs cut off.

Station mark: A stone post, 36 by 8 by 8 inches, set 30 inches in the ground and having a bronze triangulation tablet cemented in the top.

Reference mark: The lone trimmed signal tree, distant 31.6 feet, true azimuth 142° 00′.

[Latitude 38° 33′ 38.81.″ Longitude 81° 23′ 19.30″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Gunstock	81	25	17.7	261	21	08.9	3.989963
Spencer	188	16	19.5	8	17	33.7	4.300063
Nichols	230	07	11.1	- 50	10	47.7	4.039000
Pilot	279	20	14.7	99	29	50.6	4.355851

COUNTSVILLE, ROANE COUNTY.

(Not occupied. Position unchecked.)

On a high cleared knob, 0.25 mile east of Countsville post-office and 100 yards east of Walton road.

Station mark: A tall locust tree having a flag in top.

[Latitude 38° 41′ 40.4″. Longitude 81° 26′ 15.2″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Gunstock							4.2351
Spencer							3.930

CRAIG, ROANE COUNTY.

About 5 miles northeast of Spencer, on a bald hill just north of fence around graveyard, on land of Scott Craig and 0.25 mile southeast of his residence. The hill is high and prominent, having three oak trees along a fence row on the north, and a peach orchard covers the east side of knob.

Station mark: A freestone post, dressed, 36 by 8 by 8 inches, set 30 inches in ground, in center of top of which is cemented a bronze triangulation tablet.

[Latitude 38° 50′ 01.09″. Longitude 81° 18′ 46.48″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Spencer	19	25	39.82	199	24	03.39	4.0483462
Poplar	32	28	11.53	212	26	35.13	3.8398566
Ball	94	50	47.55	274	47	04.47	3.9350141
Weed	119	18	17.36	299	11	08.45	4.2760014
Lukens	183	50	49.06	3	51	01.25	3.8436737
Rattlesnake	232	40	46.59	52	45	14.47	4.1117250
Mule	304	18	39.00	124	28	02.00	4.4202690
Desert	308	28	56.20	128	34	26.10	4.2107520

NICHOLS, ROANE COUNTY.

On the high peaked top of a very large rock, 4 miles south of Looneyville, 2 miles northeast of Kester post-office, and 1 mile south of Vineyard Gap, on land owned by Lige Nichols, who lives 0.25 mile northwest of summit in hollow.

Signal: A lone snaggy tree.

Station mark: A bronze triangulation tablet cemented in solid rock.

Reference marks: The lone snaglike signal tree, distant 29.2 feet, due south.

[Latitude 38° 37′ 26.30″. Longitude 81° 17′ 32.02″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Campbell	50	10	47.7	230	07	11.1	4.039300
Gunstock	64	55	13.1	244	47	27.6	4.300013
Spencer	156	34	45.3	336	32	22.5	4.142326
Pilot	307	28	30.7	127	34	30.5	4.245792

POPLAR, ROANE COUNTY.

About 1.5 miles southwest of Spencer, on a high bald knob on north side of which stands a lone poplar tree 20 inches in diameter with a broken top. Signal is lone poplar tree.

Station mark: A rough sandstone post, 30 by 14 by 5 inches, set 24 inches in the ground, in center of top of which is countersunk and cemented a bronze triangulation tablet.

Reference marks: Arrow head cut in solid rock nearly east and 38.25 feet from station mark; the lone poplar signal tree is distant 29.9 feet, true azimuth 190° 47′.

[Latitude 38° 46′ 51.84″. Longitude 81° 21′ 20.30″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Spencer	0 02 00.03	180 01 59.96	3.6726746
Staats	127 19 37.73	307 14 11.76	4.1976405
Ball	143 24 47.25	323 22 40.70	3.9122159
Lukens	198 04 02.62	18 05 51.27	4.1291083
Craig	212 26 35.13	32 28 11.53	3.8398566

SPENCER, ROANE COUNTY.

On a high, cleared knob with a few scattering trees, 5 miles south of Spencer and 1 mile northeast of Speed post-office, on land belonging to Mr. Spencer, who lives on east side of hill.

Station mark: A stone post 36 by 8 by 8 inches, set 30 inches in the ground, in the top of which is cemented a bronze triangulation tablet.

[Latitude 38° 44′ 19.22″. Longitude 81° 21′ 20.42″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Campbell	8 17 33.70	188 16 19.50	4.3006630
Gunstock	30 36 21.20	210 30 57.80	4.3915080
Countsville			3.9366700
Poplar	180 01 59.96	360 02 00.03	3.6726746
Craig	199 24 03.39	19 25 39.82	4.0483462
Rattlesnake	217 16 22.43	37 22 26.53	4.3637765
Mule	279 32 54.50	99 43 53.50	4.4119030
Weed	307 46 15.50	127 54 42.90	4.3964679
Pilot	320 13 28.90	140 21 51.70	4.4843080
Nichols	336 32 22.50	156 34 45.30	4.1423360

STAATS, ROANE COUNTY.

On the highest part of the bare, sharply rounded south knob of a double-headed mountain, the north knob of which is wooded, about 3 miles southeast of Liverpool and 1 mile northwest of Latimer, on land owned by W. T. Staats, whose house is in the valley.

Station mark: A sandstone post 36 by 9 by 9 inches, set 30 inches in the ground, in center of top of which is cemented a bronze triangulation tablet.

[Latitude 38° 52′ 01.49″. Longitude 81° 30′ 00.23″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Reynolds	59 58 09.35	239 50 50.09	4.2906180
Ballis	137 16 22.34	317 12 31.56	4.1152546
Weed	177 35 16.45	357 35 10.40	3.7416364
Ruble	227 07 48.19	47 15 22.24	4.3750482
Ball	291 16 19.98	111 19 30.49	3.9154940
Poplar	307 14 11.76	127 19 37.73	4.1976405

WEEDY, ROANE COUNTY.

On a high, bare, cultivated knob 5 miles east of Newton and 2 miles southeast of Uler post-office, on land belonging to J. J. Smith, who lives at foot of hill on north side.

Signal: A lumber tripod.

Station mark: A stone post 36 by 8 by 8 inches, set 30 inches in the ground, and having a bronze triangulation tablet cemented in center of top.

[Latitude 38° 36′ 04.66″. Longitude 81° 07′ 48.40″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Pilot	1	07	10.3	181	07	06.1	3.9144300
Spencer	127	54	42.9	307	46	15.5	4.3954670
Mule	208	06	15.6	28	08	46.4	4.0930600
Gip	238	55	44.0				4.1769700

RUBLE, WIRT COUNTY.

On a very high, wooded knob at south end of ridge, 2.5 miles north of Burning Springs, at head of Two Run on east and Charleston Run on west, on land owned by C. L. Ruble, who lives on the northeast side of ridge. It is about 0.25 mile east of the Ruble log church. Locust trees cover east side of the summit.

Station mark: A sandstone post 36 by 9 by 9 inches, set 36 inches in the ground, in the center of top of which is cemented a bronze triangulation tablet.

[Latitude 39° 00′ 44.10″. Longitude 81° 17′ 57.79″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Lukens	3	08	14.74	183	07	56.34	4.1101241
Staats	47	15	22.24	227	07	48.19	4.3750402
Weed	59	01	48.11	238	54	07.75	4.3132201
Balis	76	05	30.89	255	54	05.29	4.4319366
Windy	94	29	37.09	274	20	57.36	4.2992679
Jephany	111	45	25.77	291	41	08.73	4.0240129
Freed	148	42	28.80	328	38	06.99	4.2831913
Rattlesnake	322	45	40.06	142	49	37.84	4.1777789

WEED, WIRT, JACKSON, AND ROANE COUNTIES.

At highest point of a cultivated knob on boundary of Wirt, Jackson, and Roane counties, 3 miles northeast of Liverpool, on land of D. W. Dougherty, whose residence, a small log house, is situated 200 feet northeast of the station, at a slightly lower elevation. Station is about 7 feet east of fence and about 100 feet south of road. (No boundary post was found.)

Station mark: A sandstone post 36 by 9 by 9 inches, set 33 inches in the ground, in the center of top of which is cemented a bronze triangulation tablet.

[Latitude 38° 56′ 00.21″. Longitude 81° 30′ 09.86″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	Meters.
Balls	115	16	15.75	295	12	30.91	3.9789552
Windy	169	30	34.12	349	29	35.35	4.0915321
Jephany	208	12	38.91	28	16	02.67	4.2168738
Ruble	238	54	07.75	59	01	48.11	4.3132201
Lukens	277	32	54.51	97	40	15.91	4.2326080
Craig	299	11	08.45	119	18	17.36	4.2760014
Ball	317	04	39.56	137	08	05.22	4.0645923
Staats	357	35	10.40	177	35	16.45	3.7416364

WISCONSIN.

PRIMARY TRAVERSE.

DANE COUNTY.

CROSS PLAINS QUADRANGLE.

The following geographic positions were determined by primary traverse in 1905 by George T. Hawkins, topographer. The line starts from Coast and Geodetic Survey astronomic pier at Madison and follows highways west to the edge of the Cross Plains quadrangle; thence south, west, north, east, and south to the point where the line first touched the quadrangle. The line is connected with the Norwegian Church spire, a United States Coast and Geodetic Survey triangulation station near Mount Horeb. Positions are given on approximate United States standard datum.

Geographic positions along highways.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Madison astronomic station	43	04	30.6	89	24	07.3
T. 7 N., R. 8 E., corner secs. 13, 14, 23, and 24, crossroads	43	04	31.3	89	30	08.6
T. 7 N., R. 8 E., hub at corner secs. 23, 24, 25, and 26, crossroads	43	03	38.7	89	30	09.6
T. 7 N., R. 8 E., corner secs. 25, 26, 35, and 36, T road east	43	02	46.7	89	30	11.4
Township line, east-west road on same	43	01	54.0	89	30	42.3
Blizzard (J.) house, across road in front of, 6 feet north of telegraph pole, in sec. 2, on southeast side of road running northeast and southwest, iron post stamped "Prim. Trav. Sta. No. 7, 1905"	43	01	29.7	89	31	11.1
Verona, five corners, 2 miles north of	43	00	57.9	89	32	00.7
Verona, road north 2 miles north by 1.5 miles west of	43	00	47.0	89	33	46.9
Rs. 7 and 8 E., line between	43	00	35.3	89	36	07.8
Clantorf, T road north	43	00	35.1	89	37	18.6
Clantorf, 1,800 feet west of, on south side of road, 2 feet north of wire fence, iron post stamped "Prim. Trav. Sta. No. 8, 1905"	43	00	29.8	89	37	42.0
Norwegian Church, three corners 0.75 mile southeast of	43	00	09.8	89	40	37.0
Norwegian Church spire	43	00	21.5	89	41	29.1
T. 6 N., Rs. 6 and 7 E., quarter corner between secs. 7 and 12	43	00	36.7	89	43	14.5
Mount Horeb, in northeast part of, 40 feet northeast of creamery and 5 feet southwest of corner of wire fence, iron post stamped "Prim. Trav. Sta. No. 9, 1905"	43	00	45.5	89	43	45.7
Tps. 6 and 7 N., R. 6 E., quarter corner between secs. 1 and 36	43	01	55.2	89	43	51.3
Cheese factory, three corners	43	04	06.0	89	43	44.9
Creamery, T road west	43	05	24.1	89	44	12.6
Tps. 7 and 8 N., R. 6 E., corner secs. 2, 3, 34, and 35	43	07	08.3	89	45	33.5
Black Earth, in southwest part of, on west side of north-south road and 200 feet south of forks to northwest, iron bench-mark post stamped "Prim. Trav. Sta. No. 10, 1905"	43	08	03.8	89	44	58.2

Geographic positions along Chicago, Milwaukee and St. Paul Railway between Black Earth and Roxbury.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Black Earth, road crossing at three corners about 1.5 miles northwest of	43	09	13.9	89	46	07.8
Mazomanie, Catholic Church spire	43	10	23.4	89	47	30.9
T. 8 N., R. 6 E., corner secs. 2, 3, 10, and 11, four corners	43	11	29.5	89	45	33.4
Tps. 8 and 9 N., R. 6 E., Chicago, Milwaukee and St. Paul Rwy., at township line crossing	43	12	22.1	89	45	08.7
On north side of east-west road, 410 feet east of railroad and 2 feet south of wire fence, iron post stamped "Prim. Trav. Sta. No. 11, 1905"	43	14	58.5	89	43	30.2
T. 9 N., Rs. 6 and 7 E., corner secs. 13, 18, 19, and 24	43	14	58.6	89	43	11.3
T. 9 N., R. 7 E., corner secs. 17, 18, 19, and 20, T road south	43	14	59.2	89	42	00.0
Roxbury, crossroads	43	14	58.8	89	40	30.5
T. 9 N., R. 7 E., sec. 23, three corners near by, T road west	43	14	32.2	89	38	05.7

Geographic positions along highways.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
T. 9 N., R. 7 E., in sec. 24, on east side of road running northwest and southeast, 6 feet west of fence and 1,900 feet northwest of stone church painted white, iron post stamped "Prim. Trav. Sta. No. 12, 1905"	43	14	50.8	89	36	21.5
T. 9 N., Rs. 7 and 8 E., quarter corner between secs. 19 and 24	43	14	32.6	89	36	02.0
T. 9 N., R. 8 E., quarter corner between secs. 19 and 20, T road north	43	14	33.4	89	34	51.6
T. 9 N., R. 8 E., corner secs. 20, 21, 28, and 29	43	14	08.1	89	33	39.4
T. 9 N., R. 8 E., corner secs. 21, 22, 27, and 28, crossroads	43	14	08.7	89	32	27.4
T. 8 N., R. 8 E., corner secs. 22, 23, 26, and 27, T road north	43	14	09.8	89	31	15.7
T. 9 N., R. 8 E., 0.25 mile east and 440 feet south of corner secs. 22, 23, 26, and 27, east side of north-south road, 2 feet west of wire fence, iron post stamped "Prim. Trav. Sta. No. 13, 1905"	43	14	05.4	89	30	57.2
T. 9 N., R. 8 E., four corners in south part of sec. 26	43	13	27.3	89	30	22.3
Tps. 8 and 9 N., R. 8 E., crossing of township line between	43	12	25.0	89	30	22.7
Schoolhouse, T road south	43	12	11.1	89	30	04.9
Schoolhouse, crossroads	43	10	39.0	89	29	47.0
T. 8 N., R. 8 E., quarter corner between secs. 13 and 24	43	09	46.8	89	29	29.9
T. 8 N., R. 8 E., quarter corner between secs. 25 and 36	43	08	01.2	89	29	29.5
Tps. 7 and 8 N., R. 8 E., quarter corner between secs. 1 and 36, 770 feet north of, 3 feet from wire fence, on west side of north-south road, iron post stamped "Prim. Trav. Sta. No. 14, 1905"	43	07	32.1	89	29	29.5
Pheasant Branch, three corners	43	06	15.2	89	29	33.2

ROCK AND WALWORTH COUNTIES.

DELAVAN, JANESVILLE, AND SHOPIERE QUADRANGLES.

Geographic positions in these quadrangles were obtained by primary traverse in 1905 by George T. Hawkins, topographer. The line starts from the position of the crossroads 2.75 miles northeast of Janesville, follows highways south, east, and north near the borders of the Shopiere quadrangle, and is connected with the city school at Janesville, the Congregational Church spire at Beloit, and the adjusted position of bench-mark post No. 8, 1904, 6.5 miles south of Whitewater.

It also extends from the southwest corner of the Delavan quadrangle east and north to the Yerkes Observatory.

JANESVILLE QUADRANGLE (ROCK COUNTY).

Geographic positions along highways.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Janesville, four corners 2.75 miles northeast of	42	43	12.2	88	59	47.6
Janesville, dome of city school	42	40	55.1	89	00	57.1
T. 2 N., Rs. 12 and 13 E., quarter corner between secs. 7 and 12, T road west	42	38	58.4	89	00	41.9
T. 2 N., Rs. 12 and 13 E., quarter corner between secs. 13 and 18, crossroads	42	38	05.9	89	00	41.6
On east side of north-south road, 2 feet from wire fence, D. A. Beckus's house bears N. 30° W., distant 340 feet, iron post stamped "Prim. Trav. Sta. No. 1, 1905"	42	37	03.5	89	00	41.1
T. 2 N., Rs. 12 and 13 E., corner secs. 25, 30, 31, and 36, crossroads	42	35	55.2	89	00	41.1
Tps. 1 and 2 N., Rs. 12 and 13 E., corner secs. 1, 6, 31, and 36, crossroads.	42	35	03.2	89	00	39.9
T. 1 N., Rs. 12 and 13 E., corner secs. 1. 6, 7, and 12, crossroads	42	34	06.8	89	00	40.0
T. 1 N., Rs. 12 and 13 E., quarter corner between secs. 19 and 24, T road west	42	31	56.1	89	00	41.8
Beloit, Congregational Church spire	42	30	05.7	89	01	39.7

SHOPIERE QUADRANGLE (ROCK COUNTY).

Geographic positions along highways.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Beloit, 2 miles east of, 870 feet east of Chicago, Milwaukee and St. Paul Rwy., on south side of east-west road, 2 feet north of wire fence, iron post stamped "Prim. Trav. Sta. No. 2, 1905"	42	30	24.4	88	59	52.4
T. 1N., R. 13 E., corner secs. 27, 28, 33, and 34, T road south	42	30	36.1	88	57	22.5
T. 1 N., R. 13 E., quarter corner between secs. 26 and 35, T road south	42	30	33.7	88	55	25.9
T. 1 N., Rs. 13 and 14 E., corner secs. 25, 30, 31, and 36, crossroads	42	30	30.9	88	53	38.8
Salisbury (L. A.) house, 260 feet northeast of, on south side of east-west road, 2 feet from wire fence, iron post stamped "Prim. Trav. Sta. No. 3, 1905"	42	30	29.6	88	52	37.6
T. 1 N., R. 14 E., quarter corner on south side of sec. 32, State line	42	29	36.3	88	51	52.8
T. 1 N., R. 14 E., quarter corner between secs. 27 and 34, crossroads	42	30	24.9	88	49	31.9
T. 1 N., R. 14 E., corner secs. 25, 26, 35, and 36	42	30	23.6	88	47	45.8
T. 1 N., R. 14 E., quarter corner between secs. 29 and 32, 1,600 feet west of, north side of east-west road, 3 feet from plank fence, iron post stamped "Prim. Trav. Sta. No. 4, 1905"	42	30	24.6	88	45	11.5
T. 1 N., R. 15 E., corner secs. 29 and 32, crossroads	42	30	25.2	88	44	30.2
T. 1 N., R. 15 E., corner secs. 28 and 33, crossroads	42	30	27.4	88	43	28.8

DELAVAN QUADRANGLE (WALWORTH COUNTY).

Geographic positions along highways.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
T. 1 N., R. 15 E., quarter corner between secs. 21 and 28, T road west	42	31	19.8	88	43	38.7
T. 1 N., R. 15 E., quarter corner between secs. 9 and 16, crossroads	42	33	04.2	88	43	38.6
Tps. 1 and 2 N., R. 15 E., quarter corner between secs. 4 and 33	42	34	51.1	88	43	38.2
T. 2 N., R. 15 E., center of sec. 27, crossroads	42	36	00.6	88	43	38.7
Darien, 1.25 miles northwest of, north side of road at head of north-south road, 2 feet from wire fence, iron post stamped "Prim. Trav. Sta. No. 6, 1905"	42	36	40.7	88	43	39.1
Turtle Creek, T road east 0.25 mile north of	42	37	53.1	88	44	32.7
Turtle Creek, T road west 0.75 mile north of	42	38	18.8	88	44	32.9
Township line, four corners 1 mile south of	42	39	11.0	88	44	33.9
Tps. 2 and 3 N., R. 15 E., corner secs. 4, 5, 32, and 33, crossroads	42	40	03.7	88	44	14.9
T. 3 N., R. 15 E., quarter corner between secs. 28 and 29, crossroads	42	41	22.3	88	44	17.8
Richmond, 0.75 mile southeast of, T road east	42	42	27.2	88	44	20.6
T. 3 N., R. 15 E., quarter corner between secs. 5 and 8, 70 feet southwest of schoolhouse, district No. 5, at southwest corner of school yard, 6.5 miles south of Whitewater, 35 feet northeast of crossroads, iron post stamped "Prim. Trav. Sta. No. 8, 1904"	42	44	24.7	88	44	58.1
T. 1 N., R. 15 E., corner secs. 26, 27, 34, and 35, crossroads	42	30	30.1	88	41	54.5
T. 1 N., R. 15 E., at corner secs. 25, 26, 35, and 36, crossroads	42	30	31.8	88	40	44.2
T. 1 N., Rs. 15 and 16 E., corner secs. 25, 30, 31, and 36, crossroads	42	30	33.8	88	39	34.5
T. 1 N., R. 16 E., corner secs. 29, 30, 31, and 32, crossroads	42	30	34.4	88	38	18.0
T. 1 N., R. 16 E., corner secs. 29, 30, 31, and 32, 330 feet east of, on north side of east-west road, iron post stamped "Prim. Trav. Sta. No. 5, 1905"	42	30	34.6	88	38	13.0
T. 1 N., R. 16 E., corner secs. 28, 29, 32, and 33, crossroads	42	30	34.2	88	37	07.8
T. 1 N., R. 16 E., corner secs. 27, 28, 33, and 34, crossroads	42	30	33.3	88	35	56.1
T. 1 N., R. 16 E., quarter corner between secs. 21 and 22, crossroads	42	31	52.4	88	35	57.3
T. 1 N., R. 16 E., quarter corner between secs. 15 and 16, crossroads	42	32	44.4	88	35	57.8
T. 1 N., R. 16 E., quarter corner between secs. 10 and 11, crossroads	42	33	36.4	88	34	48.2
Yerkes Observatory dome	42	34	13.6	88	33	23.5

DODGE, MILWAUKEE, OZAUKEE, AND WASHINGTON COUNTIES.

CLYMAN, HARTFORD, PORT WASHINGTON, WAUKESHA; AND WESTBEND QUADRANGLES.

The following geographic positions were determined by George T. Hawkins, topographer, in 1905. The line starts from bench mark No. 16, 1904, 3 miles north of Ashippun, follows highways north near the border of the Clyman quadrangle to the northwest corner of the Hartford quadrangle, thence east to Lake Michigan; starting from the northeast corner of the Westbend quadrangle, it runs southward to bench mark No. 22, 1904, at North Greenfield.

The line is tied to Woodland triangulation station of the United States Lake Survey, to Kewaskum triangulation station of the United States Geological Survey, and to primary traverse position at Belgium, 1901.

HARTFORD QUADRANGLE (DODGE AND WASHINGTON COUNTIES).

Geographic positions along highways.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Ashippun, 3 miles north of, iron post No. 16, 1904	43	16	07.5	88	31	54.4
Tps. 9 and 10 N., R. 17 E., corner secs. 5, 6, 31, and 32, T road east	43	16	59.1	88	31	05.[illegible]
T. 10 N., R. 17 E., corner secs. 29, 30, 31, and 32, T road east	43	17	51.8	88	31	06.0
Neosho, T road east	43	18	38.2	88	31	05.5
T. 10 N., R. 17 E., corner secs. 17, 18, 19, and 20, crossroads	43	19	35.3	88	31	04.[illegible]
T. 10 N., R. 17 E., quarter corner sec. 5, north side of, T road south	43	22	14.4	88	30	[illegible]
Woodland triangulation station, in SW. ¼ sec. 33, Herman Township, 1.12 miles east of Woodland railway station and 10 meters north of middle of road, on Herman-Rubicon township line. Height of station used was 47 feet. Station mark: A stone post 2.5 feet below surface. Reference marks: Three stone posts—one S. 1° 38′ E., distant 17.07 meters; one S. 87° 46′ 26″ W., distant 320.59 meters, and one S. 88° 41′ 24″ E., distant 484.49 meters. Height of ground at station, 607.2 feet	43	22	14.8	88	29	[illegible]
T. 11 N., R. 17 E., south corner secs. 31 and 32, 240 feet north and 10 feet east of, on east side of north-south road, iron post stamped "Prim. Trav. Sta. No. 15, 1905"	43	22	16.7	88	30	03.[illegible]
T. 11 N., R. 17 E., south corner secs 31 and 32, T road north	43	22	14.3	88	30	03.[illegible]
T. 11 N., R. 17 E., corner secs. 29, 30, 31, and 32, crossroads	43	23	06.4	88	30	00.6
T. 11 N., R. 17 E., corner secs. 19, 20, 29, and 30, crossroads	43	23	58.6	88	30	[illegible]
T. 11 N., R. 17 E., corner secs. 17, 18, 19, and 20, crossroads	43	24	50.7	88	30	00.5
T. 11 N., R. 17 E., corner secs. 7, 8, 17, and 18, crossroads	43	25	42.5	88	30	00.5
T. 11 N., R. 17 E., corner secs. 5, 6, 7, and 8, crossroads	43	26	34.7	88	29	59.7
Tps. 11 and 12 N., R. 17 E., corner secs. 5, 6, 31, and 32, T road west	43	27	25.1	88	29	59.4
T. 12 N., R. 17 E., corner secs. 29, 30, 31, and 32, crossroads	43	28	17.5	88	29	59.[illegible]
T. 12 N., R. 17 E., quarter corner between secs. 29 and 30, crossroads	43	28	43.7	88	29	56.[illegible]
T. 12 N., R. 17 E., 966 feet west of quarter corner between secs. 29 and 30, north side of east-west road, iron post stamped "Prim. Trav. Sta. No. 16, 1905"	43	28	43.8	88	30	12.[illegible]
T. 12 N., R. 16 E., quarter corner between secs. 25 and 30, T roads	43	28	44.5	88	31	[illegible]
Mayville, T road east 1 mile south of	43	28	46.5	88	32	46.[illegible]
T. 12 N., R. 17 E., quarter corner between secs. 28 and 29	43	28	43.7	88	28	47.4
T. 12 N., R. 17 E., corner secs. 23, 24, 25, and 26, T road north	43	29	08.8	88	25	12.[illegible]
T. 12 N., Rs. 17 and 18 E., 16 feet north and 42 feet west of corner secs. 19, 30, 24, and 25, north side of east-west road, iron post stamped "Prim. Trav. Sta. No. 17, 1905," elevation 1,026.072 feet	43	29	09.5	88	24	02.[illegible]
T. 12 N., Rs. 17 and 18 E., corner secs. 19, 30, 25, and 24, T road west	43	29	09.3	88	24	01.6
Rock River, iron bridge over, center of	43	28	33.6	88	22	55.9
T. 12 N., R. 18 E., corner secs. 27, 28, 33, and 34, T road south	43	28	16.2	88	20	30.4
T. 12 N., R. 18 E., corner secs. 26, 27, 34, and 35, crossroads	43	28	14.6	88	19	18.4
T. 12 N., R. 18 E., corner secs. 25, 26, 35, and 36, T road south	43	28	14.4	88	18	06.2
T. 12 N., Rs. 18 and 19 E., corner secs. 25, 30, 31, and 36, crossroads	43	28	14.2	88	16	54.6
T. 12 N., Rs. 18 and 19 E., corner secs. 25, 19, 24, and 30, T road east	43	29	06.8	88	16	53.6
T. 12 N., Rs. 18 and 19 E., corner secs. 18, 19, 24, and 13, T road east	43	29	59.3	88	16	53.2
T. 12 N., R. 19 E., corner secs. 17, 18, 19, and 20, 450 feet east of, on north side of east-west road, 3 feet south of wire fence, iron post stamped "Prim. Trav. Sta. No. 18, 1905"	43	29	59.0	88	15	33.6

WESTBEND QUADRANGLE (OZAUKEE AND WASHINGTON COUNTIES).

Geographic positions along highways.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
T. 12 N., R. 19 E., corner secs. 16, 17, 20, and 21, crossroads	43	29	57.9	88	14	[illegible]
T. 12 N., R. 19 E., corner secs. 15, 16, 21, and 22, crossroads	43	29	56.7	88	13	17.[illegible]
Three corners, 40 feet west of, 2 feet north of wire fence, iron post stamped "Prim. Trav. Sta. No. 19, 1905," adjusted elevation 968.749 feet	43	29	48.0	88	10	[illegible]
T. 12 N., Rs. 19 and 20 E., corner secs. 13, 18, 19, and 24, crossroads	43	29	55.3	88	09	[illegible]
T. 12 N., Rs. 19 and 20 E., corner secs. 17, 18, 19, and 20, crossroads	43	29	54.0	88	08	[illegible]
T. 12 N., R. 20 E., corner secs. 16, 17, 20, and 21, T road south	43	29	53.5	88	07	[illegible]
T. 12 N., R 20 E., corner secs. 15, 16, 21, and 22, crossroads	43	29	53.1	88	06	01.4
T. 12 N., R. 20 E., corner secs. 13, 14, 23, and 24, crossroads	43	29	53.5	88	03	36.[illegible]
T. 12 N., R. 20 E., corner secs. 13, 14, 23, and 24, 55 feet south and 15 feet east of, on east side of north-south road, iron post stamped "Prim. Trav. Sta. No. 20, 1905," adjusted elevation 847.971 feet	43	29	52.9	88	03	36.[illegible]
T. 12 N., Rs. 20 and 21 E., corner secs. 18, 19, 24, and 13, T road north	43	29	53.6	88	02	34.5
T. 12 N., R. 21 E., corner secs. 16, 17, 20, and 21, crossroads	43	29	54.0	88	00	01.4

PORT WASHINGTON QUADRANGLE (OZAUKEE COUNTY.)

Geographic positions along highways.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
T. 12, R. 21 E., corner secs. 15, 16, 21, and 22, T road west	43	29	55.0	87	58	49.5
T. 12 N., R. 21 E., corner secs. 13, 14, 23, and 24, crossroads	43	29	57.4	87	56	25.8
T. 12 N., Rs. 21 and 22 E., corner secs. 13, 18, 19, and 24, T road south	43	29	58.7	87	55	13.5
T. 12 N., R. 22 E., corner secs. 17, 18, 19, and 20, crossroads	43	29	58.3	87	54	00.8
T. 12 N., R. 22 E., corner secs. 16, 17, 20, and 21, crossroads	43	29	58.2	87	52	48.7
T. 12 N., R. 22 E., corner secs. 15, 16, 21, and 22, crossroads	43	29	58.1	87	51	37.1
Belgium station	43	29	55.2	87	51	17.0
T. 12 N., R. 22 E., corner secs. 13, 14, 23, and 24, crossroads	43	29	58.2	87	49	13.3
T. 12 N., Rs. 22 and 23 E., corner secs. 18, 19, 24, and 13, crossroads	43	29	57.6	87	48	02.2
T. 12 N., Rs. 22 and 23 E., corner secs. 18, 19, 24, and 13, 30 feet north and 15 feet east of, iron post stamped "Prim. Trav. Sta. No. 21, 1905"	43	29	57.9	87	48	02.0
Fredonia, crossroads 0.75 mile north of	43	29	01.9	87	59	24.5
T. 12 N., R. 21 E., quarter corner between secs. 28 and 33, T road north	43	28	09.6	87	59	24.1
T. 12 N., R. 21 E., south quarter corner between secs. 33 and 34, T road north	43	27	18.0	87	58	47.6
T. 11 N., R. 21 E., north corner secs. 3 and 4, T road south	43	27	18.0	87	58	48.7
T. 11 N., R. 21 E., corner secs. 3. 4, 9, and 10, crossroads	43	26	25.1	87	58	49.1
T. 11 N., R. 21 E., corner secs. 9, 10, 15, and 16, crossroads	43	25	32.7	87	58	49.5
T. 11 N., R. 21 E., corner secs. 15, 16, 21, and 22, crossroads	43	24	40.4	87	58	49.5
T. 11 N., R. 21 E., corner secs. 27, 28, 33 ,and 34, crossroads	43	22	55.7	87	58	47.8
T. 12 N., R. 21 E., south corner secs. 33 and 34, T road north	43	22	03.6	87	58	46.8
T. 11 N., R. 21 E., south corner secs. 33 and 34, 16 feet south of, on south side of east-west road, 3 feet north of stone fence, iron post stamped "Prim. Trav. Sta. No. 22, 1905"	43	22	03.4	87	58	46.8
T. 10 N., R. 21 E., corner secs. 2, 3, 10, and 11, crossroads	43	21	06.4	87	59	06.0
T. 10 N., R. 21 E., corner secs. 10, 11, 14, and 15, crossroads	43	20	14.6	87	59	05.0
T. 10 N., R. 21 E., corner secs. 14, 15, 22, and 23, crossroads	43	19	22.6	87	59	04.4
T. 10 N., R. 21 E., corner secs. 27, 28, 33, and 34, crossroads	43	17	36.5	88	00	14.2
T. 9 N., R. 21 E., north corner secs. 3 and 4, T road north	43	16	44.4	88	00	13.7
T. 10 N., R. 21 E., south corner secs. 33 and 34, T road north	43	16	44.4	88	00	13.2
T. 9 N., R. 21 E., corner secs. 3, 4, 9, and 10, crossroads	43	15	55.4	88	00	12.5

WAUKESHA QUADRANGLE (WASHINGTON AND WAUKESHA COUNTIES.)

Geographic positions along highways.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
T. 9 N., R. 21 E., corner secs. 9, 10, 15, and 16, 2,000 feet south of, on east side of north-south road, iron post stamped "Prim. Trav. Sta. No. 23, 1905"	43	14	45.9	88	00	11.7
T. 9 N., R. 21 E., corner secs. 15, 16, 21, and 22, crossroads	43	14	10.4	88	00	11.7
T. 9 N., R. 21 E., corner secs. 21, 22, 27, and 28, crossroads	43	13	18.1	88	00	12.0
T. 9 N., R. 21 E., corner secs. 27, 28, 33, and 34, crossroads	43	12	25.9	88	00	12.3
Tps. 8 and 9 N., R. 21 E., corner secs. 3, 4, 33 and 34, crossroads	43	11	33.3	88	00	13.0
T. 8 N., R. 21 E., corner secs. 3, 4, 9, and 10, crossroads	43	10	40.6	88	00	14.7
T. 8 N., R. 21 E., corner secs. 9, 10, 15, and 16, crossroads	43	09	47.9	88	00	15.8
T. 8 N., R. 21 E., corner secs. 15, 16, 21, and 22, crossroads	43	08	55.6	88	00	18.2
T. 8 N., R. 21 E., corner secs. 21, 22, 27, and 28, crossroads	43	08	02.8	88	00	19.8
T. 8 N., R. 21 E., corner secs. 21, 22, 27, and 28, 1,760 feet south of, 1 foot east of wire fence, on north-south road, iron post stamped "Prim. Trav. Sta. No. 24, 1905"	43	07	45.7	88	00	20.6
T. 8 N., R. 21 E., south corner secs. 33 and 34, T road north	43	06	20.3	88	00	21.2
T. 7 N., R. 21 E., north corner secs. 3 and 4, T road south	43	06	20.3	88	00	23.8
T. 7 N., R. 21 E., corner secs. 3, 4, 9, and 10, crossroads	43	05	24.2	88	00	25.0
T. 7 N., R. 21 E., corner secs. 9, 10, 15, and 16, crossroads	43	04	31.7	88	00	25.5
T. 7 N., R. 21 E., corner secs. 15, 16, 21, and 22, crossroads	43	03	39.2	88	00	25.9
North Greenfield, iron post No. 22, 1904	43	00	36.7	88	00	47.6

WESTERN DIVISION OF TOPOGRAPHY.

E. M. Douglas, *Geographer in charge.*

CALIFORNIA.

TRIANGULATION STATIONS.

COLUSA AND YOLO COUNTIES.

COPAY, COLUSA, DUNNIGAN, RUMSEY, AND WOODLAND QUADRANGLES.

In 1905 C. F. Urquhart, topographer, extended triangulation over five 15-minute quadrangles in the Sacramento Valley, in cooperation with the State of California. Positions are based on Yolo northwest base and southeast base, United States standard datum, of the Coast and Geodetic Survey.

ARBUCKLE, COLUSA COUNTY.

(Not occupied.)

Station mark: The spire on Baptist Church in Arbuckle, in the southwest part of town, near the schoolhouse.

[Latitude 39° 00′ 54.526″. Longitude 122° 03′ 23.352″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Foothill	56	32	48.78	236	27	42.49	4.1478049
Stovall	116	31	54.06	296	21	24.88	4.4260583
Franklin	219	46	32.38	39	48	03.97	3.7530770
Gallup	348	04	13.70	168	05	41.30	4.2108251

ASH, COLUSA COUNTY.

On a hill in Mr. Ash's pasture, about 6 miles west and one-half mile north of Arbuckle. The road from Arbuckle to Rumsey passes one-half mile south of the station, at a point about one-fourth mile west of the schoolhouse on Sand Creek. At this point there is a wire gate leading into the Jones ranch, thence up old grade to the fence between the Jones and Ash ranches.

Signal: A lumber quadripod about 14 feet high.

Station mark: An iron bench-mark post set in ground under center of signal.

[Latitude 39° 01′ 15.437″. Longitude 122° 09′ 45.363″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Stovall	127	26	37.83	307	20	12.48	4.2671365
Webster	240	41	46.26	60	44	55.60	3.9184686
Arbuckle	273	58	49.67	94	02	53.26	3.9644111

BARN, COLUSA COUNTY.

(Not occupied.)

The cupola on large barn owned by Mr. Morris, about 6 miles north of Arbuckle.

Station mark: Center of cupola.

[Latitude 39° 06′ 03.067″. Longitude 122° 03′ 17.193″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Foothill	34	31	25.57	214	26	15.11	4.3212151
Stovall	95	42	28.43	275	31	57.88	4.3825774
Franklin	326	09	55.18	146	11	26.06	3.7942240

COLLEGE CITY; COLUSA COUNTY.

(Not occupied.)

Station mark: The spire on church in College City, about 3 miles east of Arbuckle, a station on the Southern Pacific Railroad.

[Latitude 39° 00′ 14.459″. Longitude 122° 00′ 23.592″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Foothill	67	56	45.06	247	49	45.74	4.2386071
Stovall	115	02	15.56	294	49	56.26	4.4928252
Franklin	172	46	14.18	352	45	55.64	3.7499138

COLUSA, COLUSA COUNTY.

(Not occupied.)

The station is the top of what seemed to be a large, high water tank in Colusa. Windows showed in the square-shaped building, and on top there was a round tank.

[Latitude 39° 12′ 55.137″. Longitude 122° 00′ 12.870″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Franklin	3	05	25.41	183	05	00.07	4.2529963
Foothill	28	34	02.06	208	26	55.03	4.5329373
Stovall	70	06	15.28	249	53	47.53	4.4806461

FOOTHILL, COLUSA COUNTY.

On a small bald point about 12 miles southwest of Arbuckle. There is a good road from Arbuckle to Pat. Molalley's ranch, on Petroleum Creek, a distance of 7 miles; thence up the creek 4 miles to a cabin, and about one-fourth mile beyond the cabin up left-hand creek to place where a cabin has been burned. There is a small shack standing and an old well. At this place wagon will have to be left. Thence up creek on horseback or foot between one-fourth and one-half mile, thence up ridge to left.

Signal: A tree set in the ground.

Station mark: An iron bench-mark post set in the ground near the signal tree.

[Latitude 38° 56′ 43.005″. Longitude 122° 11′ 30.267″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Stovall	148	13	35.26	328	08	16.29	4.3637285
Williams	188	11	45.10	8	13	13.94	4.3736454
Colusa	208	26	55.03	28	34	02.06	4.5329373
Barn	214	26	15.11	34	31	25.57	4.3212151
Webster	218	02	34.18	38	06	49.38	4.1992516
Franklin	231	40	21.81	51	47	02.84	4.2907543
Arbuckle	236	27	42.49	56	32	48.78	4.1478049
College City	247	49	45.74	67	56	45.06	4.2386071
Johns	266	09	54.15	86	18	17.22	4.2856171
Smokestack	274	27	46.75	94	39	29.83	4.4315525
Dunnigan	288	23	01.06	108	31	27.83	4.3115246
Gallup	298	18	28.22	118	25	01.57	4.2342232

FRANKLIN, COLUSA COUNTY.

The pole set in the cupola of Franklin schoolhouse, about 5 miles north and east of Arbuckle and about 3 miles north of College City, about one-eighth mile south of store where road turns east to go over long bridge leading into Morman Basin.

Station mark: An iron bench-mark post set in the ground 50 feet from signal on line to Stovall station. The post is very near the fence in front of the school, between fence and northernmost hitching post.

[Latitude 39° 03′ 15.331″. Longitude 122° 00′ 53.017″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Gallup	0	44	55.09	180	44	48.19	4.3063418
Stevens	17	32	09.04	197	28	05.45	4.4921665
Arbuckle	39	48	03.97	219	46	32.38	3.7530779
Foothill	51	47	02.84	231	40	21.81	4.2907543
Webster	93	40	38.53	273	38	12.51	3.7408054
Stovall	105	25	51.87	285	13	50.73	4.4548896
Barn	146	11	26.06	326	09	55.18	3.7942240
Colusa	183	05	00.07	3	05	25.41	4.2529963
Smokestack	320	49	59.37	140	55	02.34	4.2640046
Mesa	341	58	46.76	162	03	29.20	4.5452803

JOHNS, COLUSA COUNTY.

(Not occupied.)

Station mark: The flag pole on Johns schoolhouse, about 5 miles north of Dunnigan.

[Latitude 38° 57′ 24.129″. Longitude 121° 58′ 10.026″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Gallup	24	00	48.72	203	58	59.45	4.0130554
Foothill	86	18	17.22	266	09	54.15	4.2858171
Franklin	160	06	27.64	340	04	45.06	4.0613867

SMOKESTACK, COLUSA COUNTY.

Station mark: The smokestack of pumping plant on reclamation district 108. There is a road to it down Sacramento River from Grimes post-office, but the best way is to go from Captain Hull's residence by boat. Mr. Friel, who lives 4½ miles north of Dunnigan, has a very good boat and will act as boatman. The point is also known as Howell Point. No post was put in at this station, as the only land above water was the levee.

[Latitude 38° 55′ 33.303″. Longitude 121° 52′ 51.488″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Mesa	2	17	48.31	182	17	28.37	4.2823401
Curtis	36	47	19.63	216	43	44.96	4.1391498
Stevens	53	49	05.50	233	40	00.16	4.4148425
Dunnigan	60	03	14.41	239	59	58.43	3.9384923
Gallup	63	14	09.70	243	02	39.88	3.5399159
Foothill	94	39	29.83	274	27	46.75	4.4318735
Franklin	140	55	20.34	320	49	59.37	4.2640047
Blodgett	349	17	57.53	169	18	51.31	4.0466199

STOVALL, COLUSA COUNTY.

On the highest of three peaks, known locally as the Three Sisters, on ridge in pasture of the Stovall-Wilcoxon Company. It is about 3 miles west by northwest of the Stovall residence and about 1½ miles south of the Mountain House post-office. The hill is probably 1,500 or 2,000 feet high and scattering oak and pine trees are on it. The best way to climb it is from the Mountain House, where there are accommodations for men and animals. The mountain is 11 miles from Williams and 18 from Arbuckle. There are several high trees on the northeast side of the mountain which would interfere with observations in the direction of Maxwell.

Signal: A small tree set in the ground on highest point.
Station mark: An iron bench-mark post.

[Latitude 39° 07′ 19.704″. Longitude 122° 19′ 56.753″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Colusa	249	53	47.53	70	06	15.28	4.420641
Williams	255	57	43.23	76	04	31.94	4.204798
Barn	275	31	57.88	95	42	28.43	4.382574
Franklin	285	13	50.73	105	25	51.87	4.45[illegible]
Webster	288	03	26.68	108	13	01.73	4.362[illegible]
College City	294	49	56.26	115	02	15.56	4.[illegible]
Arbuckle	296	21	24.88	116	31	54.06	4.[illegible]
Ash	307	20	12.48	127	26	37.83	4.357[illegible]
Foothill	328	08	16.29	148	13	35.26	4.353721

WEBSTER, COLUSA COUNTY.

Station mark: The cupola on schoolhouse, known as the Webster school, about 4 miles up the railroad from Arbuckle.

[Latitude 39° 03′ 26.880″. Longitude 122° 04′ 44.758″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Foothill	38	06	49.38	218	02	34.18	4.199255
Ash	60	44	55.60	240	41	46.26	3.91[illegible]
Stovall	108	13	01.73	288	03	26.68	4.362[illegible]
Franklin	273	38	12.51	93	40	38.53	3.74[illegible]

WILLIAMS, COLUSA COUNTY.

(Not occupied.)

Station mark: The cupola on large school building in Williams, a station on the Southern Pacific Railroad.

[Latitude 39° 09′ 25.252″. Longitude 122° 09′ 09.261″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Foothill	8	13	13.94	188	11	45.10	4.373[illegible]
Stovall	76	04	31.94	255	57	43.23	4.204798
Webster	330	04	31.08	150	07	17.91	4.105457

BLACKS, YOLO COUNTY.

(Not occupied.)

Station mark: The spire on church at Blacks station, or Zamora, a station on the Southern Pacific Railroad.

[Latitude 38° 48′ 06.340″. Longitude 121° 52′ 53.883″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Mesa	7	40	18.80	187	40	00.08	3.733031
Curtis	108	31	33.63	288	28	00.44	3.9371[illegible]
Blodgett	216	37	09.86	36	38	04.82	3.548276

BLODGETT, YOLO COUNTY.

A high windmill in Mr. Blodgett's yard, about 3½ miles northeast of Zamora or Blacks station, on the Southern Pacific Railroad, and about one-fourth mile from the edge of water known as the Tule. There are several windmills in the vicinity, but this is the highest and has white cloth around the derrick just below the platform.

Signal: Center of derrick.

Station mark: Iron post extending into ground.

[Latitude 38° 49′ 38.530″. Longitude 121° 51′ 25.789″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Mesa	19	04	51.16	199	03	37.55	3.9384519
Blacks	36	38	04.82	216	37	09.86	3.5492765
Curtis	89	29	43.21	269	25	15.04	4.0136002
Gallup	109	34	14.52	289	28	11.83	4.1700617
Mumma	153	03	53.68	333	01	28.58	4.0866882
Smokestack	169	18	51.31	349	17	57.53	4.0466199

BRICK HOUSE, YOLO COUNTY.

(Not occupied.)

Station mark: The chimney on a large brick house in Hungry Hollow, about 4 miles north and 1 mile east of Capay post-office.

[Latitude 38° 45′ 12.757″. Longitude 122° 01′ 28.258″].

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Stevens	113	53	14.48	293	49	33.76	3.9686716
Curtis	207	29	42.47	27	31	31.94	3.9604774
Mesa	269	59	30.93	90	04	34.51	4.0685796

CORBIN, YOLO COUNTY.

On a round prairie hill in the foothills, about 3½ miles southwest of George Scott's residence and on land owned by him, about 1.5 miles west of the Corbin ranch. Mr. Scott's residence is about 3 miles south and 1 mile west of Madison post-office.

Signal: A lumber quadripod.

Station mark: An iron bench-mark post set 40 inches in the ground.

[Latitude 38° 37′ 08.411″. Longitude 122° 02′ 33.280″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Stevens	159	38	45.52	339	35	45.78	4.2998654
Esparta	196	27	37.03	16	28	39.23	3.9290019
Mesa	221	38	12.54	41	43	56.32	4.3007868
Yolo northwest base	247	23	55.40	67	30	50.55	4.2406557
Scott	288	09	52.42	108	16	15.00	4.1937828
Winters	337	37	42.76	157	39	48.83	4.1096763

CURTIS, YOLO COUNTY.

On land of Al. Bummerly used as pasture, about 5 miles south of Dunnigan. A road leads from Dunnigan to the Curtis residence on the Bermmerly ranch, thence into the hills. Mr. Curtis or anyone at his ranch can give directions to station. It is probably the highest hill in the vicinity.

Signal: A lumber quadripod about 14 feet high with white and black cloth on it.

Station mark: An iron bench-mark post set in the ground under center of signal.

[Latitude 38° 49′ 35.365″. Longitude 121° 58′ 33.517″].

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Brick house	27	31	31.94	207	29	42.47	3.9604774
Roth	48	55	33.57	228	53	01.05	3.8917122
Stevens	71	13	44.99	251	08	14.59	4.1283773
Gallup	144	15	51.00	324	14	16.62	3.7931496
Mumma	203	29	25.02	23	31	29.38	4.0782451
Smokestack	216	43	44.96	36	47	19.63	4.1391496
Blodgett	269	25	15.04	89	29	43.21	4.0136002
Blacks	288	28	00.44	108	31	33.63	3.9371752
Mesa	317	14	25.78	137	17	40.13	4.0427295

DAVISVILLE, YOLO COUNTY.

(Not occupied.)

Station mark: Center of a very high eucalyptus tree with the limbs cut off within 15 feet of top, in the town of Davis.

[Latitude 38° 32′ 35.496″. Longitude 121° 44′ 23.477″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Yolo southeast base	72	30	06.54	252	27	52.57	3.7373120
Scott	107	03	22.57	286	58	25.53	4.0815727

DUNNIGAN, YOLO COUNTY.

(Not occupied.)

Station mark: The spire on church in Dunnigan, a station on the Southern Pacific Railroad.

[Latitude 38° 53′ 12.688″. Longitude 121° 58′ 03.530″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Stevens	50	39	19.48	230	33	30.05	4.2402921
Gallup	69	07	14.38	249	05	21.11	3.6680244
Foothill	108	31	27.83	288	23	01.06	4.3115246
Smokestack	239	59	58.43	60	03	14.41	3.9384903
Mesa	335	25	59.53	155	28	55.21	4.2115680

ESPARTA, YOLO COUNTY.

(Not occupied.)

Station mark: The pole in cupola on the large school building in Esparta, on branch line of Southern Pacific Railroad from Elmira to Rumsey.

[Latitude 38° 41′ 32.507″. Longitude 122° 00′ 53.717″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Corbin	16	28	39.23	196	27	37.03	3.9290019
Stevens	138	30	21.64	318	26	19.44	4.1491683
Mesa	238	01	00.86	58	05	42.62	4.1079913
Scott	316	18	45.36	136	24	06.08	4.2553407

FAIRVIEW, YOLO COUNTY.

(Not occupied.)

Station mark: The pole in cupola of Fairview School, on road between Dunnigan and Capay, about 6 or 7 miles from Dunnigan.

[Latitude 38° 49′ 55.005″. Longitude 122° 02′ 32.789″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Stevens	54	36	30.34	234	33	29.87	3.9306902
Gallup	205	45	50.26	25	46	45.96	3.6923959

GALLUP, YOLO COUNTY.

On a round cultivated hill, highest in vicinity, about 3 miles west-southwest of Dunnigan, a small town on the Southern Pacific Railroad. It is on land of Mr. Gallup, of Sacramento, at present rented by Mr. Dubois. A buggy can be driven to summit, but to do so one would have to go through a cultivated field. A good road from Dunnigan to Mr. Dubois's residence must be traveled, but leave it and follow divide just as his residence comes into view.

Signal: A lumber quadripod.

Station mark: An iron post under center of signal.

[Latitude 38° 52′ 18.830″. Longitude 122° 01′ 03.990″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Fairview	25	46	45.96	205	45	50.26	3.6923959
Stevens	44	08	21.96	224	04	25.74	4.1158360
Foothill	118	25	01.57	298	18	28.22	4.2342202
Franklin	180	44	48.19	0	44	55.09	4.3063418
Johns	203	58	59.45	24	00	48.72	4.0130554
Mumma	234	42	25.05	54	46	03.95	4.0123504
Smokestack	243	09	00.44	63	14	09.70	4.1237603
Dunnigan	249	05	21.11	69	07	14.38	3.6680244
Blodgett	289	28	11.83	109	34	14.52	4.1700617
Mesa	319	44	34.14	139	49	22.90	4.2359042
Curtis	324	14	16.62	144	15	51.00	3.9731496

GREEN, YOLO COUNTY.

(Not occupied.)

Station mark: Center of a high windmill in grove of Mrs. Green's yard, 1½ miles west and 9 miles south of Woodland.

[Latitude 38° 34′ 08.148″. Longitude 121° 48′ 13.514″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters*
Scott	96	27	55.24	276	25	21.54	3.7755336
Yolo southeast base	355	23	08.21	175	23	17.56	3.6546695

HINES, YOLO COUNTY.

(Not occupied.)

Station mark: Center of a very high eucalyptus tree near Mr. Hines's residence, one-half mile east of Plainfield.

[Latitude 38° 35′ 18.814″. Longitude 121° 47′ 44.868″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Yolo southeast base	2	50	01.08	182	49	52.57	3.8252855
Scott	77	17	25.12	257	14	33.53	3.8342834
Yolo northwest base	151	43	45.18	331	41	24.89	4.0574946

MESA, YOLO COUNTY.

On a rolling prairie hill in Mrs. Bemmerly's pasture, 4 miles west and 2 miles north of Yolo, about 3½ miles south of Blacks station and 1 mile west of Mr. Morgan's ranch.

Signal: Lumber quadripod with white and black cloth on it.

Station mark: An iron bench-mark post set 34 inches in the ground.

[Latitude 38° 45′ 12.531″. Longitude 121° 53′ 23.281″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Corbin	41	43	56.32	221	38	12.54	4.3007898
Esparta	58	05	42.62	238	01	00.86	4.1079913
Monticello	69	15	06.96	249	03	52.16	4.4455587
Brickhouse	90	04	34.51	269	59	30.93	4.0685796
Stevens	100	38	09.00	280	29	24.59	4.3131381
Roth	102	37	34.00	282	31	47.35	4.1365453
Curtis	137	17	40.13	317	14	25.78	4.0427295
Gallup	139	49	22.90	319	44	34.14	4.2359042
Dunnigan	155	28	55.21	335	25	59.53	4.2115960
Franklin	162	03	29.20	341	58	46.76	4.5453001
Smokestack	182	17	28.37	2	17	48.31	4.2823401
Blacks	187	40	00.08	7	40	18.80	3.7330318
Blodgett	199	03	37.55	19	04	51.16	3.9384519
Yolo	287	41	39.39	107	44	47.06	3.8809679
Woodland	309	03	31.39	129	07	55.25	4.1183305
Yolo northwest base	341	25	49.96	161	27	01.74	3.9390042
Scott	355	34	48.55	175	35	28.08	4.2982274

MONTICELLO, YOLO COUNTY.

In extreme northeast corner of sec. 4, T. 9 N., R. 3 W. of Mount Diablo meridian, the highest summit of mountain range lying between Sacramento and Berryessa valleys, about 5 miles north of Monticello, in lower portion of Berryessa Valley. May be approached from this town, from which it is visible. Location known to people in neighborhood. The lower underground mark is a metallic cartridge placed ball downward in a ½-inch hole, 1½ inches deep, drilled in bottom of a 6-inch round hole 1 foot deep excavated in sandstone rock, the top of cartridge being 2.5 feet below surface. Surface mark is a copper bolt five-eighths inch by 5 inches, with a silver pin in it, set in cement in a hole in this stone. Bolt projects one-fourth inch above stone. A rough stone theodolite pier was then built to a height of 3.84 feet and capped with a flat stone 32 inches square, 31.288 feet north and 3.687 feet east of station; the latitude pier is 31.413 feet north and 8.823 feet east of station, and the vertical-circle pier bears S. 38° 17′ E. (true) and is distant 19.786 meters from station.

[Latitude 38° 39′ 50.645″. Longitude 122° 11′ 22.327.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Vaca	343	53	24.67	163	57	21.54	4.5220726
Mount Helena	91	04	27.64	270	47	50.79	4.5863347
Diablo	344	21	34.46	164	31	50.15	4.9547254
Tamalpais	23	32	08.73	203	17	02.14	4.9517165
Stevens	203	03	32.18	23	06	03.33	4.1728090
Mesa	249	03	52.16	69	15	06.95	4.4455587
Yolo northwest base	266	35	03.73	86	47	29.67	4.4610020
Yolo southeast base	293	47	19.46	114	01	55.20	4.5700850

MUMMA, YOLO COUNTY.

About 5 miles northeast of Dunnigan, a station on the Southern Pacific Railroad, on the very flat ground about 100 feet south of the Yolo-Colusa county line and very near the overflow country known as The Tule. It is about one-fourth mile southeast from Thomas Mumma's residence, which is in Colusa County. The land on which it stands is not fenced, and a buggy can be driven to it.

Signal: A lumber quadripod about 16 feet high. To reach signal from Dunnigan, go north to county line, thence east to point.

Station mark: An iron bench-mark post set in the ground under center of signal.

[Latitude 38° 55′ 35.451″. Longitude 121° 55′ 15.382″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Curtis	23	31	29.38	203	29	25.02	4.0782451
Gallup	54	46	03.95	234	42	25.05	4.0123504
Smokestack	269	02	39.88	89	04	10.29	3.5399159
Blodgett	333	01	28.58	153	03	52.68	4.0866882

ROTH, YOLO COUNTY.

(Not occupied.)

Station mark: The chimney on Mr. Roth's residence, 5 miles north of Capay, on the Capay-Dunnigan road.

[Latitude 38° 46′ 49.244″. Longitude 122° 02′ 36.909″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Stevens	96	36	04.55	276	32	06.77	3.886753
Curtis	228	53	01.05	48	55	33.57	3.891712
Mesa	282	31	47.35	102	37	34.00	4.1365453

SCOTT, YOLO COUNTY.

On a low prairie hill with a lone locust tree on it. The land is sometimes used for grain, but it is a pasture at present. It is three-fourths mile west of Isaac Quinn's residence, which is 3 miles west and 1 mile south of Plainfield. Land is owned by George Scott.

Signal: A lumber quadripod with a black cloth on it.

Station mark: An iron bench-mark post set 30 inches in the ground.

[Latitude 38° 34′ 30.006″. Longitude 121° 52′ 20.020″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Winters	54	50	18.74	234	46	02.62	4.065800
Corbin	108	16	15.00	288	09	52.42	4.193708
Stevens	137	21	53.96	317	12	31.02	4.506405
Esparta	136	24	06.08	316	18	45.36	4.255347
Mesa	175	35	28.08	355	34	48.55	4.298274
Yolo northwest base	186	08	37.82	6	09	09.95	4.065346
Woodland	216	55	13.58	36	58	57.43	4.159246
Woodland high school	219	58	49.20	40	02	32.35	4.125725
Hines	257	14	33.53	77	17	25.12	3.934258
Green	276	25	21.54	96	27	55.24	3.778356
Davisville	286	58	25.53	107	03	22.57	4.081577
Yolo southeast base	309	13	59.56	129	16	42.54	3.912629

STEVENS, YOLO COUNTY.

On high point in Mr. Stevens's pasture, the highest bald point on the ridge in the range of hills between the Capay Valley and Hunger Hollow. To reach station, follow the Capay-Dunnigan road to Mr. Roth's residence, 5 miles from the Capay post-office, thence west 1 mile to Mr. Scheller's ranch, from which there is a good road uphill to the signal. The road is very steep 3½ or 4 miles from Mr. Scheller's to signal.

Signal: An oak tree set in ground.

Station mark: An iron bench-mark post set in ground by side of tree.

[Latitude 38° 47′ 14.791″. Longitude 122° 07′ 20.733″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Monticello	23	06	03.33	203	03	32.18	4.1728090
Franklin	197	28	05.45	17	32	09.04	4.4921667
Gallup	224	04	25.74	44	08	21.96	4.1158360
Smokestack	233	40	00.16	53	49	05.50	4.4148425
Curtis	251	08	14.59	71	13	44.99	4.1283773
Mesa	280	29	24.59	100	38	09.00	4.3131381
Yolo northwest base	297	31	16.55	117	41	12.32	4.4141826
Yolo southeast base	315	33	36.12	135	45	42.12	4.6043066
Scott	317	12	31.02	137	21	53.96	4.5064425
Corbin	339	35	45.78	159	38	45.52	4.2998654

WINDMILL, YOLO COUNTY.

(Not occupied.)

Station mark: Center of windmill about 1½ miles south-southwest of Yolo northwest base, Coast and Geodetic Survey monument.

[Latitude 38° 39′ 51.679″. Longitude 121° 52′ 07.336″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Scott	1	46	22.74	181	46	14.82	3.9966663
Winters	31	13	34.82	211	09	10.54	4.2967123

WINTERS, YOLO COUNTY.

On a prominent bald hill with large oak tree near the northwest end of it, about 1 mile southwest of Winters, on Southern Pacific Railroad from Elmira to Rumsey.

Signal: A quadripod with white and black cloth on it.

Station mark: An iron bench-mark post set 40 inches in the ground.

[Latitude 38° 30′ 42.303″. Longitude 121° 59′ 11.054″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Corbin	157	39	48.83	337	37	42.76	4.1096763
Yolo northwest base	211	01	37.33	31	06	25.84	4.3362415
Scott	234	46	02.62	54	50	18.74	4.0856900

WINTERS SCHOOL, YOLO COUNTY.

(Not occupied.)

Station mark: The pole in cupola on large school building at Winters, a town on the Elmira-Rumsey branch of the Southern Pacific Railroad.

[Latitude 38° 31′ 22.293″. Longitude 121° 58′ 22.572″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Corbin	150	23	44.84	330	21	08.53	4.069103
Scott	236	34	21.95	56	38	07.89	4.021[illegible]

WOODLAND CITY HALL, YOLO COUNTY.

(Not occupied.)

Station mark: The steeple on the city hall in Woodland.

[Latitude 38° 40′ 43.970″. Longitude 121° 46′ 21.428″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Scott	36	58	57.43	216	55	13.58	4.159[illegible]
Yolo northwest base	90	13	32.13	270	10	20.19	3.870[illegible]
Mesa	129	07	55.25	309	03	31.39	4.11[illegible]

WOODLAND HIGH SCHOOL, YOLO COUNTY.

(Not occupied.)

Station mark: The pole in cupola on the Woodland high school, about 1 mile south of the center of the town.

[Latitude 38° 40′ 04.132″. Longitude 121° 46′ 22.512″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Scott	40	02	32.35	219	58	49.20	4.12[illegible]
Yolo northwest base	99	38	53.68	279	35	42.44	3.8[illegible]
Mesa	133	07	30.01	313	03	06.85	4.14[illegible]

YOLO, YOLO COUNTY.

(Not occupied.)

Station mark: The steeple on the white church in Yolo, a town on the Southern Pacific Railroad.

[Latitude 38° 43′ 57.487″. Longitude 121° 48′ 23.410″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Yolo northwest base	36	59	38.45	216	57	42.68	3.871[illegible]
Mesa	107	44	47.06	287	41	39.39	3.8[illegible]

YOLO NORTHWEST BASE, YOLO COUNTY.

In the SE. ¼ sec. 28, T. 10 N., R. 1 E., Mount Diablo meridian, 4⅓ miles west of the railroad passing through Woodland, and immediately on the north side of county road running west toward Madison and Capay Valley.

Station mark: A needle hole in a German-silver plug in a copper bolt in top of a granite block 35 inches long by 20 inches square at the base and drest to 12 inches square at the top, having letters "U. S. C. & G. S." deeply cut on it. The top of the brick is 4½ feet below the surface and a glass hemisphere is placed over the copper bolt. The surface mark is a fine needle hole in a copper bolt set in lead on top of a granite block 25 inches square by 26 inches deep, having the letters "U. S. C. S. S. E. Yolo base" cut on it. Top of block is even with surface of ground and block itself is in center of a solid brickwork pier, having a base of 70 inches square at a depth of 50 inches below surface, battering to 54 inches square at surface. This brickwork was carried to a height of 33¼ feet above surface and capped with a granite slab 40 inches square by 8 inches thick with a 1¼-inch hole in the center. Charcoal and charcoal dust were mixt with the earth in filling around the subsurface part of the structure.

No reference marks.

[Latitude 38° 40′ 44.806″. Longitude 121° 51′ 28.553″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Yolo southeast base	343	05	07.93	163	07	18.98	4.2427032
Diablo	3	09	32.63	183	07	28.85	4.9474512
Vaca	30	25	42.34	210	17	15.66	4.5909077
Scott	6	09	09.95	186	08	37.82	4.0653494
Winters:	31	06	25.94	211	01	37.33	4.3362415
Corbin	67	30	50.55	247	23	55.40	4.2406557
Monticello	86	47	29.67	266	35	03.73	4.4610020
Stevens	117	41	12.32	297	31	16.55	4.4141826
Mesa	161	27	01.74	341	25	49.98	3.9399342
Yolo	216	57	42.68	36	59	38.45	3.8714131
Woodland city hall	270	10	20.19	90	13	32.13	3.8706276
Woodland high school	279	35	42.44	99	38	53.68	3.8752754

YOLO SOUTHEAST BASE, YOLO COUNTY.

In the NW. ¼ sec. 19, T. 8 N., R. 2 E., Mount Diablo meridian, 3⅛ miles west and 1⅛ miles south of Davisville and about 25 meters from the left bank of Putah Creek.

Station mark: Same as Yolo northwest base, viz, needle hole in german-silver plug in copper in granite block 4½ feet below surface, with another needle hole in a copper bolt in lead in a granite block even with ground, in center of a brick pier extending to a height of 33¼ feet above ground, capped by a granite block.

Reference marks: Four marks were set, consisting of granite blocks 1 foot square and 1¼ feet high, with copper bolts and drill holes on top, incased in brickwork 18 inches below surface. Two were in line to the Yolo northwest base at a distance of 18 feet $11\frac{1}{16}$ inches and 327 feet 10 inches from the center, and two were in line at right angles thereto eastward at a distance of 20 feet five-eighths of an inch and 328 feet $5\frac{5}{16}$ inches from the center.

[Latitude 38° 41′ 42.185″. Longitude 121° 47′ 58.18″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Vaca	55	49	13.77	235	38	37.32	4.477522
Diablo	7	56	54.56	187	52	41.08	4.859908
Monticello	114	01	55.20	293	47	19.46	4.570650
Scott	129	16	42.54	309	13	59.56	3.912628
Stevens	135	45	42.12	315	33	36.12	4.604306
Yolo northwest base	163	07	18.98	343	05	07.93	4.242702
Green	175	23	17.56	355	23	08.21	3.654686
Hines	182	49	52.57	2	50	01.08	3.825255
Davisville	252	27	52.57	72	30	06.54	3.737313

MARIPOSA AND TUOLUMNE COUNTIES.

YOSEMITE SPECIAL QUADRANGLE.

For the control of this special quadrangle Charles F. Urquhart, topographer, extended triangulation control from Pilot Peak and Devil Peak in 1905. Twelve stations, controlling an area of 100 square miles, were located on the United States standard datum.

CLOUDS REST, MARIPOSA COUNTY.

On the highest point of Clouds Rest, a well-known mountain at the northeast corner of the Yosemite State Park. There is a good trail from the Yosemite Valley to the summit of the mountain. Animals can be taken within 200 feet (elevation) of top.

Signal: A cairn 5 feet high, built of large, flat rocks.

Station mark: A copper bolt set in rock very near and west of cairn.

[Latitude 37° 46′ .05.58″. Longitude 119° 29′ 18.90″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Starr King	19	04	06.99	199	03	04.76	3.882151
Devil Peak	40	00	43.66	219	51	32.29	4.535196
Sentinel Dome	59	21	29.37	239	17	59.94	3.988482
Glacier Point	61	00	29.03	240	57	23.16	3.929396
Eagle	77	39	36.31	257	34	59.80	4.053736
Yosemite Point	82	00	09.13	261	56	19.84	3.966325
Flat	107	11	17.36	287	05	27.92	4.164402

DEVIL PEAK, MARIPOSA COUNTY.

At the southeast end of a short, sharp ridge, 9 miles southwest of Wawona Park, bare on top and covered with loose rock. Ascended by wagon road from Wawona. Nearest camping place is 1¼ miles northeast of summit.

Station mark: A cairn 4 feet in diameter at the base, 4½ feet high, on site of old monument, 5.6 feet west of "U. S. G. S." chiseled on rock (Urquhart, 1905). Cairn could not be found, but rock with "U. S. G. S." was found, and point used was within 2 or 3 feet of old point.

[Latitude 37° 31′ 46.79″. Longitude 119° 44′ 23.09″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Cottonwood	180	37	19.76	00	37	31.81	4.6445464
Hoffman	209	50	37.68	29	59	03.70	4.6092431
Conness	217	07	08.88	37	22	32.54	4.7855484
Clarks Peak	235	55	55.04	56	07	20.30	4.5212361
Red	244	35	09.78	64	47	16.70	4.5097490
Kaiser	297	47	02.53	118	07	16.04	4.7451616
Big Shuteye	305	41	47.10	125	53	10.71	4.5325137
Bullion Mount	96	31	08.21				4.4740000
Pilot	146	23	49.18	326	16	39.63	4.4928478
Flat	194	51	35.15	14	54	59.19	4.5030993
Clouds Rest	219	51	32.29	40	00	43.66	4.5381966

DEWEY, MARIPOSA COUNTY.

On the bluff overlooking the Yosemite Valley, on south side of the valley and west of Bridal Veil Creek. It can be reached by trail either from Glacier Point or Fort Monroe. Distance from Fort Monroe to station is about 4 miles. Trail is known as Pohono trail.

Signal: A small fir tree placed in a crack in the rock with rock piled around its base.

Station mark: A triangulation tablet cemented in rock at the foot of tree.

[Latitude 37° 42′ 16.03″. Longitude 119° 39′ 06.31″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
El Capitan	201	24	41.54	21	25	14.24	3.5544804
Eagle	215	33	40.67	35	35	03.79	3.7572966
Sentinel Dome	250	37	44.55	70	40	14.60	3.8039652

EAGLE, MARIPOSA COUNTY.

On the summit of Eagle Peak, a well-known point on the north side of Yosemite Valley. There is a good trail known as the Yosemite Point and Eagle Peak trail from the valley to station.

Signal: An iron rod about 4 feet high set in rock. It is necessary to have a flag of some kind on rod.

Station mark: A triangulation tablet cemented in rock at foot of rod.

[Latitude 37° 44′ 46.90″. Longitude 119° 36′ 50.46″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Dewey	35	35	03.79	215	33	40.67	3.7572966
El Capitan	56	55	46.25	236	54	55.83	3.3815967
Yosemite Point	239	01	46.76	59	02	33.99	3.3429966
Clouds Rest	257	34	59.80	77	39	36.31	4.0537206
Valley	275	40	32.04	95	41	26.92	3.3435064
Glacier Point	295	05	15.94	115	06	46.50	3.6021166
Sentinel Dome	313	28	34.14	133	29	41.12	3.5674215

EL CAPITAN, MARIPOSA COUNTY.

(Not occupied.)

On the highest point of El Capitan, nearest the bluff. The Eagle Peak trail continues on to this mountain.

Station mark: A cairn on highest point.

[Latitude 37° 44′ 04.28″. Longitude 119° 38′ 12.86″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Eagle	236	54	55.83	56	55	46.25	3.3815967
Sentinel Dome	284	37	43.60	104	39	40.99	3.6842312
Dewey	21	25	14.24	201	24	41.54	3.5544804

FLAT, MARIPOSA COUNTY.

On the summit of a flat-topt rocky peak at the source of West Fork of Yosemite Creek and about 5 miles from junction of Eagle Peak and Yosemite Point trails. There is no trail at this point, but animals can be taken to foot of peak. The south side is probably the easiest to climb. About 300 feet inaccessible for animals.

Signal: A cairn with dead tree inside of it.

Station mark: A triangulation tablet set in rock under the cairn.

[Latitude 37° 48′ 25.17″. Longitude 119° 38′ 49.20″]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Devil Peak	14	54	59.19	194	51	35.15	4.5131993
Pilot	79	10	59.75	259	00	24.24	4.4124125
Clouds Rest	287	05	27.92	107	11	17.36	4.1644432
Starr King	315	03	17.42	135	08	04.35	4.2106574
Yosemite Point	319	24	08.84	139	26	08.84	3.8673613
Sentinel Dome	328	54	57.80	148	57	17.54	4.0343807

GLACIER POINT, MARIPOSA COUNTY.

At the east end of iron railing at Glacier Point, a well-known point on the south side of Yosemite Valley. There is a good trail known as the Glacier Point trail from the valley to the station.

Signal: A pole about 25 feet high set in rock.

Station mark: A triangulation tablet set in rock.

[Latitude 37° 43′ 51.85″. Longitude 119° 34′ 22.50″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Eagle	115	06	46.50	295	05	15.94	3.6021166
Valley	136	00	48.03	316	00	12.34	3.3128519
Yosemite Point	148	30	53.24	328	30	09.89	3.5210068
Clouds Rest	240	57	23.16	61	00	29.03	3.9293950

PILOT PEAK, MARIPOSA AND TUOLUMNE COUNTIES.

On boundary of Mariposa and Tuolumne counties. Rose's ranch is 2.5 miles east.

Station mark: A new cairn with tree in it was built and the greater portion of brush cut. Triangulation tablet set in loose rock and a flat rock with a cross cut on it placed immediately over it. The tree in center of cairn is over center of cross.

[Latitude 37° 45′ 46.57″. Longitude 119° 56′ 06.42″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Flat	259	00	24.24	79	10	59.75	4.4124128
Sentinel Dome	277	56	30.06	98	09	24.64	4.4953983
Devil Peak	326	16	39.63	146	23	49.18	4.4928478
Moccasin Peak	97	52	44.00	277	38	19.00	4.5424939
Big Canyon	144	46	11.00	324	39	25.00	4.4473833

SENTINEL DOME, MARIPOSA COUNTY.

On the summit of Sentinel Dome, a well-known peak on the south side of Yosemite Valley. The Glacier Point trail continues south and west along the bluff to Fort Monroe. This trail passes Sentinel Dome about 1 mile from Glacier Point Hotel.

Signal: The trunk of a tree with large spreading top.

Station mark: A triangulation tablet set in rock under center of signal tree. The tree stands above anything else on mountain.

[Latitude 37° 43′ 24.46″. Longitude 119° 35′ 01.02″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Dewey	70	40	14.60	250	37	44.55	3.8039652
Pilot	98	09	24.64	277	56	30.06	4.4953983
El Capitan	104	39	40.99	284	37	43.60	3.6862312
Eagle	133	29	41.12	313	28	34.14	3.5674215
Flat	148	57	17.54	328	54	57.80	4.0343607
Yosemite Point	167	51	35.66	347	51	15.89	3.5750603
Clouds Rest	239	17	59.94	59	21	29.37	3.9884838
Starr King	290	47	27.31	110	49	54.39	3.7993631

STARR KING, MARIPOSA COUNTY.

(Not occupied.)

Station is on highest point of Mount Starr King, a well-known mountain on the southeast side of Yosemite Valley. Very difficult to climb.

Station mark: Cairn on the summit.

[Latitude 37° 42′ 11.86″. Longitude 119° 31′ 00.58″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Sentinel Dome	110	49	54.39	290	47	27.31	3.7986631
Flat	135	08	04.35	315	03	17.42	4.2108574
Clouds Rest	199	03	04.76	19	04	06.99	3.8821534

VALLEY, MARIPOSA COUNTY.

In the Yosemite Valley, on the north side of junction of roads to Camp Yosemite and Mirror Lake and about 50 yards from bridge over Merced River, near the Sentinel Hotel. Signal is a 4 by 4 inch post set in ground, with signboard pointing to Mirror Lake on it. Another board at right angles to signboard and post.

Station mark: A concrete pier 2½ feet high, 20 by 20 inches at base, 12 by 12 inches at top, in the top of which was placed an aluminum plug marked "△ U. S. G. S. B. M.," over which was placed an aluminum plate, one-half inch thick by 4½ inches wide, 7 inches long, engraved as follows:

U. S. Geological Survey,
Charles D. Walcott, Director,
Latitude 37° 44′ 40″
Longitude 119° 35′ 21″
Elevation above sea, 3,960 feet,
1095.

[Latitude, 37° 44′ 39.81″. Longitude, 119° 35′ 20.80″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Eagle	95	41	26.92	275	40	32.04	3.3435984
Yosemite Point	167	13	43.08	347	13	35.42	3.1417253
Glacier Point	316	00	12.34	136	00	48.03	3.3128519

YOSEMITE POINT, MARIPOSA COUNTY.

At the west end of iron railing on Yosemite Point, a well-known point overlooking Yosemite Valley. There is a good trail known as the Yosemite Point and Eagle Peak trail to station. The pole is not straight, so the part at top of railing was sighted.

Station mark: A triangulation tablet cemented in rock at foot of pole.

[Latitude, 37° 45′ 23.65″. Longitude, 119° 35′ 33.31″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Eagle	59	02	33.99	239	01	46.76	3.3428995
Flat	139	26	08.84	319	24	08.84	3.8673813
Clouds Rest	261	56	19.84	82	00	09.13	3.9663925
Glacier Point	328	30	09.89	148	30	53.24	3.5210068
Valley	347	13	35.42	167	13	43.08	3.1417253
Sentinel Dome	347	51	15.89	167	51	35.66	3.5750603

CALIFORNIA-NEVADA.

TRIANGULATION STATIONS.

ESMERALDA AND NYE COUNTIES, NEV.; INYO COUNTY, CAL.

AMARGOSA REGION.

During the field season of 1905–6 triangulation control was extended over a large part of southern Nye County, Nev., and a small area adjacent to Death Valley, in Inyo County, Cal., by R. H. Chapman and B. D. Stewart, topographers. The work was more of a reconnaissance than a standard nature and was done in connection with topographic surveys, which were carried on rapidly. The foresights were made to the natural points selected, and signals were erected when the points were occupied for observations. The stations were marked and signals erected according to regulations of the Survey. The instruments used were the standard 8-inch theodolites reading to 2 seconds of arc.

The scheme was carried forward from the line Lone Mountain-Montezuma, the first a primary and the second a secondary or tertiary point of the United States Coast and Geodetic Survey. The value of this base is taken from finally adjusted figures in the scheme brought from points in California during 1905 by Mr. Urquhart. The initial position is that given for Lone Mountain by the Coast Survey, and is on the United States standard datum.

Figures were extended about 1½° eastward from Lone Mountain and tied to the secondary Coast Survey point Kawich, which was occupied, and by long, unclosed sights to the primary point White Pine.

From these figures the scheme was carried southward to the Death Valley region and tied to triangulation points Grape and Nye, established by the Coast Survey in connection with the survey of the Nevada-California oblique boundary.

In all cases the preliminary positions, azimuths, and distances agreed so closely with those given by the Coast Survey that no figure adjustment was made, it being considered that the preliminary methods of field work and the small differences found did not warrant the labor of the operation.

In connection with the general scheme small areas were controlled by local triangulation at Goldfield and Bullfrog.

A list of points and positions at check points is appended.

BOUNDARY, INYO COUNTY, CAL.

On highest of group of summits in lower Grapevine Mountains, about 10 miles west of Rose's Well, on the Bullfrog-Las Vegas road 20 miles southwest of Bullfrog, 1 mile southeast of Chloride Cliff, and 5 miles from Keane Springs. Can be easily reached from any of above points with pack animals.

Station mark: A bronze triangulation tablet in solid rock under center of a cairn 7 feet high.

[Latitude 36° 41′ 36.45″. Longitude, 116° 51′ 48.47″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Tin	112 17 55	291 56 39	4.75625
Grape	139 54 35	319 44 18	4.59686
Bare	216 03 58	36 09 36	4.37354
Cane	261 16 06	81 40 46	4.79303
Furnace	325 55 36	146 04 36	4.60556

DEATH, INYO COUNTY, CAL.

Westernmost and highest of group of bare rounded summits south and east of Bullfrog-Ballarat wagon road. About 15 miles north of west of Furnace Creek ranch, 10 miles southwest of Salt Creek, and 10 miles northeast of Emigrant Spring, on wagon road just mentioned. The peak is locally known as Tucki or Sheep Mountain. It is easily ascended by taking trail east over ridge 0.25 mile north of Emigrant Spring to divide toward Death Valley, thence northwest about 4 miles.

Station mark: A bronze triangulation tablet cemented in block of stone 16 by 14 by 10 inches, under a small heap of stones and flagstaff 9 feet high.

[Latitude 36° 30′ 00.61″. Longitude 117° 07′ 47.28″.]

To station—	Azimuth.	Back azimuth.	Log distance.
	° ′ ″	° ′ ″	*Meters.*
Tin	145 57 07	325 45 14	4.71493
Grape	178 03 37	358 02 54	4.71332
Bare	222 49 03	43 04 13	4.74454

FURNACE, INYO COUNTY, CAL.

(Not occupied.)

A high, rocky peak, southernmost in Amargosa Range, about 15 miles east of Furnace Creek ranch (Death Valley), 6 miles west-southwest of Lee's well, and 10 miles northwest of Franklin well, Amargosa Desert. Local name, Pyramid Peak. It was ascended on foot from the southeast.

Station mark: A bronze triangulation tablet set in slab of black limestone and surmounted by cylindrical cairn 7.5 feet high and 5 feet in diameter.

Reference marks: Cross cut in solid rock about 20 feet southwest, cross cut in solid rock about 30 feet north.

[Latitude 36° 23′ 32.15″. Longitude 116° 36′ 42.09″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Boundary	146	04	36	325	55	36	4.60556
Bare	170	51	48	350	48	24	4.72672
Timber	189	52	34	9	57	59	4.89419

GRAPE, INYO COUNTY, CAL.

Highest peak of Grapevine Range, 20 miles northwest of Bullfrog and 15 miles from Thorp's mill, which is on Bullfrog-Goldfield wagon road; nearest water is spring on Bullfrog-Grapevine ranch trail about 5 miles northwest. Station is one used by Coast Survey in establishing Nevada-California boundary line. Center left by the survey found and occupied. No additional marks made.

Station mark: Drill hole one-half by one-half inch in rock 14 by 12 by 10 inches, over which is monument 4 feet high and flagstaff.

[Latitude 36° 57′ 56.40″ (36° 57′ 55.21″[a]). Longitude 117° 08′ 57.73″ (117° 08′ 58.04″[a]).]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Tin	72	21	38	252	10	36	4.45705
Gold Mountain	156	33	46	336	28	08	4.54060
Tolicha	221	48	45	42	01	02	4.65454
Timber	257	18	09	77	42	03	4.79779
Jumbo	273	02	52	93	16	06	4.51472
Cane	283	18	38	103	53	41	4.95088
Bare	285	27	46	105	43	43	4.61240
Boundary	319	44	18	139	54	35	4.59698
Death	358	02	54	178	03	37	4.71332
Nye[a]	305	29	00				3.68880
Nye	305	28	30				3.68850

[a] By Coast and Geodetic Survey.

TELESCOPE PEAK, INYO COUNTY, CAL.

(Not occupied.)

Highest peak of Panamint or Telescope Range.

[Latitude 36° 11′ 49.20″. Longitude 117° 04′ 26.92″.]

TIN, INYO COUNTY, CAL.

Highest and northernmost peak of Panamint Range; 15 miles southwest of Stainingers (Grapevine) ranch, 10 miles southwest of Mesquite Spring, and 6 miles north and a little west of Piñon Spring. Easily reached from south by trail to Gold Belt (old mining camp), which is 18 miles south of peak, thence north along trail to Rest and Burro springs, thence north along crest to point.

Signal: Tripod 6 feet high with flagstaff 10 feet higher.

Station mark: A bronze triangulation tablet cemented in solid rock.

Reference marks: None.

[Latitude 36° 53′ 13.13″. Longitude 117° 27′ 20.10″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Gold	198	12	03	18	18	33	4.63054
Grape	252	10	36	72	21	38	4.45705
Boundary	291	56	39	112	17	55	4.75638
Death	325	45	14	145	57	07	4.71483

ANDESITE, ESMERALDA COUNTY, NEV.

Highest knoll on top of lava flow about 3 miles south of Goldfield, 1 mile west of road to Lida.

Station mark: Bronze triangulation tablet in solid rock on highest point of hill.

Reference marks: Cross in solid rock 17 feet southwest, cross in solid rock 15.5 feet southeast.

Signal: A small local monument, the Great Star Lode claim location monument.

[Latitude 37° 40′ 18.30″. Longitude 117° 14′ 16.49″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Montezuma	103	15	33	283	11	01	4.04886
Columbia	190	22	42	10	23	10	3.79819
Diamond	229	21	21	49	24	43	4.02794

COLUMBIA, ESMERALDA COUNTY, NEV.

High hill immediately northeast of Columbia, on large mass of rock at summit, locally known as Columbia Mountain.

Station mark: A bronze triangulation tablet cemented in solid rock under a cairn 6.5 feet high.

Reference marks: No. 1, 17.6 feet south in solid rock; No. 2, 23.25 feet east-northeast, in solid rock.

[Latitude 37° 43′ 38.76″. Longitude 117° 13′ 30.22″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Andesite	10 23 10	190 22 42	3. 79819
Diamond	263 43 36	83 46 30	3. 84505

GOLD MOUNTAIN, ESMERALDA COUNTY, NEV.

On highest summit of Gold Mountain a sharp, rocky peak 1.5 miles southeast of Oriental post-office (abandoned), now known as Old Town or Old Camp, and about 20 miles southeast of Lida post-office. Best reached from Old Camp, where there is good water and feed, and which is reached from Lida post-office by a good wagon road. (Wheeler point, 1871–72?)

Station mark: A bronze triangulation tablet in solid rock, stamped "8144 V A," under a rock monument 6 feet high.

[Latitude 37° 15′ 09.50″. Longitude 117° 18′ 18.09″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Tin	18 18 38	198 12 03	4. 63054
Montezuma	174 12 45	354 10 41	4. 69316
Stonewall	220 27 07	40 36 47	4. 55844
Tolicha	267 34 42	87 52 41	4. 64285
Grape	336 28 08	156 33 46	4. 54060

LONE MOUNTAIN, ESMERALDA COUNTY, NEV.

A station of the Coast Survey on a prominent, well-known peak in a dry, desert country, 60 miles by road in a southerly direction from Cloverdale and 40 miles easterly from Columbus. The nearly extinct mining camps of Montezuma and Silver Peak lie 25 miles southwesterly and southeasterly, respectively, from the mountain. The geodetic point is marked by a cross on a one-half inch copper bolt leaded in a drill hole in a solid ledge of slate, around which is the usual stone and brick foundation pier for theodolite, surrounded by a stone wall 15.5 feet in diameter, with an opening to the northeast.

The vertical-circle pier, 71.1 feet distant from geodetic point and surrounded by a stone ring wall 10.7 feet in diameter, with northeast opening, was left standing. Reference marks are four drill holes—one north, distant 9.15 feet; one north-northeast, distant 13.78 feet; one south-southeast, distant 21.59 feet, and one a little north of west, distant 8.2 feet from geodetic point.

In 1902 a large signal was placed over the above station.

[Latitude 38° 01′ 28.759″. Longitude 117° 29′ 37.647″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Mount Grant	118	30	45.13	297	42	31.46	5.10932745
Toiyabe Dome	187	47	26.93	7	52	43.32	4.9570034
Cactus Peak	296	08	52.00	116	31	36.00	4.78170
Diamond	316	23	25.00	136	36	13.00	4.64768
Stonewall	325	21	47.00	145	38	27.00	4.84866
Montezuma	342	18	57.00	162	23	49.00	4.5645027

MONTEZUMA, ESMERALDA COUNTY, NEV.

On highest point of group of mountains about 8 miles west of Goldfield, locally known as Montezuma Peak. It is about 1.5 miles south of old Montezuma mill and springs and is a secondary point of the Coast Survey.

Station mark: A bronze triangulation tablet in block of stone 24 by 10 by 10 inches, partly buried, over which is a cairn 6 feet high, with small brush in top.

Reference marks: Cross cut in solid rock 25.6 feet west; cross cut in solid rock 17.4 feet east.

[Latitude 37° 41′ 41.3″. Longitude 117° 21′ 41.2″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Lone Mountain	162	23	49	342	18	57	4.5645027
Cactus Peak	256	56	58	77	14	55	4.64124
Stonewall	307	06	58	127	18	45	4.55260
Gold Mountain	354	10	41	174	12	45	4.60016

TIMPAHUTE, LINCOLN COUNTY, NEV.

(Secondary point. Not occupied.)

Highest point on Timpahute Range.

[Latitude 37° 26′ 58.26″. Longitude 115° 43′ 55.57″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Belted Peak	113	43	32	293	31	01	[illegible]
Reveille	141	46	54	321	32	08	[illegible]

BARE, NYE COUNTY, NEV.

On high, bare summit of very rocky ridge 2 miles southeast of Beatty post-office and 6 miles east of Bullfrog. Camp may be made at spring 1 mile south of Beatty post-office in wash at west foot of Bare Mountain. The climb may be made with instrument mule, but is rather difficult. Wheeler monument was removed, but no center found. Under monument was small tin cylindrical case 4 inches by 0.75 inch, within which was the following: "Explorations and Surveys West of 100th Meridian. Name of peak, Bare Mountain; triangulation station No. 7; approx. altitude, 5,800 feet. Party No. 2, executive officer, Lieut. R. Birnie; topographical ass't, Louis Nell; meteorological ass't, Stevens. En route from Panamint to C. Independence. Date: Sept. 16, 1875. Corps of Engineers, U. S. Army."

Station mark: A ½-inch drill hole in rock 12 by 12 by 4 inches under a rock monument 7 feet high.

[Latitude 36° 51′ 59.10″. Longitude 116° 42′ 23.74″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Boundary	36	09	36	216	03	58	4. 37584
Death	43	04	13	222	49	03	4. 74454
Grape	105	43	43	285	27	46	4. 61240
Yellow	122	53	29	302	48	32	4. 16348
Jumbo	143	41	19	323	38	35	4. 05819
Tolicha	168	22	17	348	18	32	4. 65842
Timber	221	37	24	41	46	16	4. 51761
Furnace	350	48	24	170	51	48	4. 72672

BEATTY, NYE COUNTY, NEV.

On top of rocky summit of andesite-capped hill of dark color 1.5 miles northwest of Beatty and 1 mile east of Montgomery-Shoshone mine.

Station mark: A bronze triangulation tablet cemented in solid rock under a rock monument 5 feet high.

[Latitude 36° 55′ 06.28″. Longitude 116° 47′ 16.78″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Busch	85	53	23	265	51	34	3. 65317
Yellow	113	12	18	293	10	17	3. 73[illegible]32
Jumbo	187	55	18	7	55	30	3. 54085

BELTED PEAK, NYE COUNTY, NEV.

Highest point of bare, rocky mountain 2 miles south of northernmost point of Kawich-Groom road where it crosses Belted Range; about 15 miles a little north of east of Kawich post-office. Nearest water is Cliff Spring, 5 miles to the south, on west slope of range. Horses can go within 0.25 mile of top (from south).

Station mark: A cross cut in solid rock.

Signal: A cairn 7.5 feet high over mark.

Reference marks: An arrow 27.4 feet east-northeast, cut in rock; a similar arrow 30.1 feet south-southeast, cut in rock, with U S G S cut on left side of arrow.

[Latitude 37° 34′ 07.83″. Longitude 116° 04′ 31.56″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Mesa	19	48	48	199	42	42	4.62570
Quartzite	74	33	23	254	24	20	4.35021
Kawich	142	12	51	321	58	44	4.74245
Reveille	170	34	16	350	32	20	4.50604

BUSCH, NYE COUNTY, NEV.

On high, rocky, gray point known as Busch Peak on Bonanza Mountain, 1 mile west of Rhyolite. Easily reached with animals by trail.

Station mark: A bronze triangulation tablet under a mineral location post to which black and white flags were attached.

[Latitude 36° 54′ 55.78″. Longitude 116° 50′ 18.13″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Yellow	168	32	34	348	32	22	3.39957
Jumbo	232	49	12	52	51	13	3.79462
Beatty	265	51	34	85	53	23	3.65317

CACTUS PEAK, NYE COUNTY, NEV.

On highest point of north peak of Cactus Range, about 25 miles east of Goldfield and 35 miles southeast of Tonopah. It is northernmost peak of range and a local landmark over a large area. A monument 6 feet high was found, which was removed and a new one erected on its site.

Station mark: A bronze triangulation tablet in block of stone 3 by 2 by 1 foot, resting on surface, over which is a cairn 9 feet high and 5.5 feet in diameter at base.

[Latitude 37° 46′ 58.44″. Longitude 116° 52′ 38.49″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Stonewall	24	35	09	204	29	12	4.53750
Montezuma	77	14	55	256	56	58	4.64124
Lone Mountain	116	31	36	296	08	52	4.78170
Kawich	241	24	45	61	40	05	4.61994
Quartzite	301	12	31	121	32	50	4.75831

CANE, NYE COUNTY, NEV.

Highest point on flat ridge running east and west, on north edge of mesa about 6 miles almost due west of Cane Spring, 22 miles northeast of Ash Meadows. Easily ascended with horses.

Station mark: A bronze triangulation tablet in solid rock 10 feet from edge of bluff under a cairn 8 feet high, 7 feet in diameter at base.

Reference marks: Cross cut in solid rock 38 feet southwest of center; cross cut in solid rock 44 feet southeast of center.

[Latitude 36° 46′ 35.48″. Longitude 116° 10′ 33.05″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Boundary	81	40	46	261	16	06	4.79303
Grape	103	53	41	283	18	38	4.95088

CHALK MOUNTAIN, NYE COUNTY, NEV.

(Secondary point. Not occupied.)

Highest point of rocky ridge about 20 miles east of Kawich post-office and 10 miles east of Belted Range.

[Latitude 37° 31′ 52.90″. Longitude 115° 55′ 12.62″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Belted Peak	106	55	22	286	49	42	4.15649
Reveille	152	09	23	332	01	30	4.60750

DIAMOND, NYE COUNTY, NEV.

On hill 3 miles northeast of Goldfield and 3.5 miles east-southeast of Diamondfield; about 0.75 mile to the east is another hill which is slightly higher.

Station mark: Bronze triangulation tablet in solid rock on highest point of hill.

Reference marks: Cross in solid rock 33.7 feet southeast of tablet; cross in solid rock 14.3 feet west-northwest of tablet.

Signal: Cairn 8 feet high on large rock.

[Latitude 37° 44′ 03.46″. Longitude 117° 08′ 46.04″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Andesite	49	24	43	229	21	21	4.02791
Montezuma	77	04	10	256	56	16	4.28973
Lone Mountain	136	36	13	316	23	25	4.64768
Columbia	190	22	42	10	23	10	3.79819
Stonewall	340	02	35	160	06	29	4.44101

FORTY (SHOSHONE MOUNTAIN), NYE COUNTY, NEV.

(Secondary point. Not occupied.)

Highest point on Shoshone Mountain about 15 miles northwest of Cane Springs, east of Fortymile Canyon.

[Latitude 36° 57′ 05.09″. Longitude 116° 18′ 28.05″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Boundary	160	10	13	239	50	13	4.75774
Cane	328	44	31	148	49	15	4.35601

JUMBO, NYE COUNTY, NEV.

On high summit 2 miles east of Indian Springs, near Rhyolite; the springs may be reached from Rhyolite by good wagon road and station is accessible with pack animals.

Station mark: Drill hole in solid rock under a rock monument 6 feet high.

[Latitude 36° 56′ 57.92″. Longitude 116° 46′ 57.43″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Beatty	7	55	30	187	55	18	3.54065
Busch	52	51	13	232	49	12	3.79462
Yellow	76	35	02	256	32	49	3.74956
Grape	93	16	06	273	02	52	4.51472
Bare	323	38	35	143	41	19	4.05639

KAWICH, NYE COUNTY, NEV.

On highest peak of Kawich Range, about 3 miles east of Longstreet's ranch, 6 miles northeast of Silverbow (camp), and 4 miles west of Eden (camp). Easily ascended by stock trails from any of above places. There are springs south and northeast of station 1 mile distant.

Station mark: A bronze triangulation tablet cemented in solid rock under a cairn 7 feet high.

[Latitude 37° 57′ 42.67″. (37° 57′ 43.05″ a) Longitude 116° 27′ 39.16″ (116° 27′ 39.62″ a).]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Cactus Peak	61	40	05	241	24	45	4.6199400
Lone Mountain	94	43	06	274	04	30	4.9590009
Lone Mountain a	94	42	15	274	04	06	4.9589870
White Pine	244	27	00	65	02	35	4.9687800
White Pine a	244	26	29	65	02	02	4.9686134
Reveille	292	36	38	112	48	39	4.4922300
Belted Peak	321	58	44	142	12	51	4.7424500
Quartzite	346	12	58	166	18	02	4.7049600

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a By Coast and Geodetic Survey.

MAL, NYE COUNTY, NEV.

(Not occupied.)

The highest rocky conical mountain in the Cactus Range, about 10 miles southeast of Cactus Spring, from which it is plainly visible, and about 3 miles almost due west of Antelope Springs.

Station mark: A small cairn found on mountain.

[Latitude 37° 37′ 41.10″. Longitude 116° 45′ 32.32″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Stonewall	60	19	16	240	09	01	4.45572
Cactus Peak	148	45	31	328	41	11	4.30335

MESA (PAHUTE), NYE COUNTY, NEV.

On highest point of high ridge, southern boundary of plateau, about 12 miles a little south of west from Oak Spring, 10 miles west of Whiterock Spring, and 6 miles north-northeast of tank on Oak Spring, Indian Camp trail; at west end of ridge having scattering piñon and cedar trees on top, but bare on salient west of station. Horses can be ridden to station from tank to the southwest.

Signal: Piñon tree trimmed, with pole nailed in top carrying a white flag and bunch of green.

Station mark: Bronze triangulation tablet in solid rock.

Reference marks: Middle nail of 4-inch blazed piñon stump, 37.2 feet northeast; nail in blaze on piñon stump, 15 feet west.

[Latitude 37° 12′ 38.32″. Longitude 16° 14′ 12.14″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Quartzite	167	13	49	347	10	55	4.53821
Belted Peak	199	42	42	19	48	48	4.62570
Wheelbarrow Peak	207	49	41	27	55	28	4.47891

QUARTZITE, NYE COUNTY, NEV.

A high, bare, rocky mountain 3 miles southwest of Kawich (Gold-Reed), locally known as Quartzite Mountain; easily ascended on horses from Kawich or almost any direction. Nearest water, Cliff Spring, about 15 miles east across flat in Belted Range, or Indian Spring, 4 miles south of Cliff Spring.

Station mark: Bronze triangulation tablet cemented in solid rock under a cairn 9 feet high with 8-foot base.

[Latitude 37° 30′ 50.78″. Longitude 116° 19′ 23.355″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Tolicha	57	49	00	237	31	16	4.70771
Stonewall	88	50	11	268	24	01	4.80171
Cactus Peak	121	32	50	301	12	31	4.75821
Kawich	166	18	02	346	12	58	4.70896
Reveille	203	40	27	23	47	21	4.61479
Belted Peak	254	24	20	74	33	23	4.35621
Wheelbarrow Peak	287	48	38	107	57	34	4.35669
Mesa	347	10	55	167	13	49	4.53821

REVEILLE, NYE COUNTY, NEV.

The southernmost, highest prominent peak of Reveille Range, about 12 miles south of New Reveille and about 12 miles a little north of east of Sumner Spring. Horses taken to summit from south.

Station mark: A bronze triangulation tablet in solid rock under a cairn 5 feet high with a brush top 3 feet higher.

[Latitude 37° 51′ 13.90″. Longitude 116° 08′ 06.48″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Quartzite	23	47	21	203	40	27	4.61479
Kawich	112	48	39	292	36	38	4.49222
White Pine	226	54	43	47	18	54	4.88056
Belted Peak	350	32	20	170	34	16	4.50604
Wheelbarrow Peak	353	35	43	173	37	48	4.65390

SHEET LINE, NYE COUNTY, NEV.

(Not occupied.)

Highest peak, north end, of low hills about 20 miles southeast of Tonopah, 30 miles northeast of Goldfield, and about 16 miles due north of Cactus Peak. Hill is about 1 mile south of "short-cut" road from Tonopah to Silverbow and Longstreet's ranch; hills are known to some as Monitor Range.

Station mark: A cairn 5 feet high.

[Latitude 37° 59′ 00.3″. Longitude 116° 53′ 35.65″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Kawich	273	28	11	93	44	08	4.58032
Cactus Peak	356	24	17	176	24	49	4.34825

STONEWALL, NYE COUNTY, NEV.

On south peak of high, rocky mountain about 20 miles southeast of Goldfield. There is very little solid rock on station; only bare broken rock, grassy. It is easily ascended with saddle horses in two hours from Stonewall, a well-known watering place, 4 miles west of north of station, by going east from spring 0.5 mile up first canyon to head, thence up ridge to top and around high ridge to peak.

Station mark: A bronze triangulation tablet in block of stone 14 by 12 by 8 inches on surface, over which a cairn 6 feet high was built.

[Latitude 37° 30′ 01.30″. Longitude 117° 02′ 22.43″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Gold Mountain	40	36	47	220	27	07	4. 55844
Montezuma	127	18	45	307	06	58	4. 55260
Lone Mountain	145	38	27	325	21	47	4. 84866
Diamond	160	06	29	340	02	35	4. 44101
Cactus Peak	204	29	12	24	35	09	4. 53750
Quartzite	268	24	01	88	50	11	4. 80171
Tolicha	321	30	17	141	47	39	4. 51599

TIMBER, NYE COUNTY, NEV.

On summit of westernmost and barest of two timber peaks, known as Timber Mountain, about 17 or 18 miles south of east of Howell ranch. Side camp can be made within 5 miles of summit with buckboard by following up wash in which runs Oak Spring trail and keeping a general southeasterly course along trail and onto long low ridge.

Station mark: A bronze triangulation tablet stamped "V A 7426" in solid rock, over which is a cairn 6 feet high with flag pole 10 feet high.

[Latitude 37° 05′ 16.77″. Longitude 116° 27′ 38.00″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Furnace	9	57	59	189	52	34	4. 89419
Bare	41	46	16	221	37	24	4. 51761
Grape	77	42	03	257	18	09	4. 79779
Tolicha	122	55	03	302	42	23	4. 56742

TOLICHA, NYE COUNTY, NEV.

On southern summit of high bare point of reddish color 20 miles north of east of Thorp's mill and about 23 miles east of south of Gold Crater. More easily reached from Farmer stage station on Goldfield-Bullfrog road by coming up first large wash which drains to south. Good water and feed at Monte Cristo Springs, 1.5 miles west of north of station. (Is point of Lieut. G. M. Wheeler, 1871–72.)

Station mark: A bronze triangulation tablet in solid rock, over which is a rock monument 6 feet high. Tablet is stamped "7031 V A."

[Latitude 37° 16′ 05.93″. Longitude 116° 48′ 36.36″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Grape	42	01	02	221	48	45	4.65454
Gold Mountain	87	52	41	267	34	42	4.64285
Stonewall	141	47	39	321	39	17	4.51599
Quartzite	237	31	16	57	49	00	4.70771
Timber	302	42	23	122	55	03	4.56742
Bare	348	18	32	168	22	17	4.65842

WHEELBARROW PEAK, NYE COUNTY, NEV.

Highest peak in belted range, about 15 miles south of east of Kawich post-office and about 2 miles north of point where trail from Indian Spring to Whiterock Spring (via Johnnies Water) crosses ridge.

Signal: Tripod, about 8 feet high, brush top.

Station mark: A bronze triangulation tablet in large bowlder.

[Latitude 37° 27′ 04.18″. Longitude 116° 04′ 42.21″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Mesa	27	55	23	207	49	41	4.47891
Quartzite	107	57	34	287	48	38	4.35069
Reveille	173	37	48	353	35	43	4.65290

WHITE PINE, NYE COUNTY, NEV.

A Coast Survey station on highest and boldest point of White Pine Mountains, called on Lieutenant Wheeler's map the Grant Range, but local name is Troy Peak. Station is near edge of precipice; the rock bluff, a few feet distant, falls almost vertically 700 or 800 feet. Geodetic point is a ⅝-inch by 4-inch copper bolt set in solid rock in center of stone foundation pier for the theodolite. A bottle, containing the approximate height and geographic position of station, was embedded in plaster of Paris in central pit of the pier above the bolt. Reference marks are three drill holes—one about northeast, distant 10.3 feet; one about south-southeast, distant 7.65 feet, and one about northwest, distant 9 feet from geodetic point. The vertical circle station is 27.62 feet distant from geodetic station in a northeasterly direction. The usual circular stone ring walls surrounding the central and the vertical circle stations, the stone cabins used for living purposes, and the bolts and drills to which the guy ropes of observing tents were fastened were left in position.

[Latitude 38° 19′ 10.90″[a] (38° 19′ 10.728″).[b] Longitude 115° 30′ 03.17″;[a] (115° 30′ 04.791″[b]).]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Wheeler Peak[b]	234	03	10.65	54	47	42.11	5.10432259
Pioche[b]	285	46	48.23	106	40	33.05	5.12178013
Kawich[b]	65	02	02	244	26	29	4.96861340
Kawich[a]	65	02	35	244	27	00	4.96878000
Reveille[a]	47	18	54	226	54	43	4.88056000

[a] From Lone Mountain, Montezuma.
[b] United States standard datum, Coast and Geodetic Survey.

YELLOW, NYE COUNTY, NEV.

On highest part of yellowish summit, 3 miles west of north of Rhyolite and 0.25 mile east of highest rocky summit of the Bullfrog Hills north of Rhyolite.

Station mark: A bronze triangulation tablet cemented in solid rock under a cairn 5 feet high.

[Latitude 36° 56′ 15.54″. Longitude 116° 50′ 38.20″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Jumbo	256	32	49	76	35	02	3.74956
Beatty	293	10	17	113	12	18	3.73432
Bare	302	48	32	122	53	29	4.16348
Busch	348	32	22	168	32	34	3.39957

TERTIARY POINTS LOCATED BY INTERSECTIONS (NEVADA).

	Latitude.			Longitude.		
AT BULLFROG.	°	″	′	°	″	′
Rocky Cap, Nye County	36	53	48.88	116	46	35.16
Ladd, Nye County	36	53	45.79	116	49	14.17
AT GOLDFIELD.						
Portland (frame), Esmeralda County	37	42	16.60	117	13	11.00
St. Ives (frame), Esmeralda County	37	42	53.08	117	12	51.39
Combination (frame), Esmeralda County	37	42	48.32	117	13	27.28
Black Butte (highest point), Esmeralda County	37	45	04.67	117	10	34.67

FRESNO, INYO, MONO, TULARE, AND TUOLUMNE COUNTIES, CAL.; ESMERALDA AND NYE COUNTIES, NEV.

HIGH SIERRA REGION, CALIFORNIA; GOLDFIELD REGION, NEVADA.

During the field seasons of 1904-5 Charles F. Urquhart, topographer, extended triangulation over an area of 7,000 square miles for the control of seven 30-minute quadrangles.

Positions are based on Conness and White Mountain south, stations of the Coast and Geodetic Survey, on the United States standard datum.

GODDARD, FRESNO COUNTY, CAL.

Ascended peak by ridge running from the southwest up from camp on south fork of San Joaquin at pasture 1½ miles above the camp of the Mount Goddard Copper Mining Company. Can take animals within 1,500 feet of summit. The south end of the mountain was occupied, although the north end is slightly higher. The south end seems to be recognized as the summit and is much easier of access.

Station mark: A bronze triangulation tablet set in loose shale rock, over which is erected a cairn 4 feet in diameter at base and 4 feet high.

[Latitude 37° 06′ 12.31″. Longitude 118° 43′ 09.20″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Three Sisters	98	03	25.99	277	51	05.29	[illegible]
Kaiser	117	18	18.97	297	01	25.41	[illegible]
Silver	146	47	11.35	326	36	13.95	[illegible]
Morgan	178	01	57.03	358	01	28.67	[illegible]
White Mountain, south	214	45	39.07	35	02	33.26	[illegible]
Split Mountain	288	56	12.20	109	06	57.48	[illegible]
Whitney	326	37	02.71	146	52	26.30	[illegible]
Brewer	334	24	33.96	154	33	01.05	[illegible]
Baldy	16	54	10.44	196	48	19.23	[illegible]
Spanish (preliminary)	35	23	57.36	215	17	45.76	[illegible]
Hilgard	161	39	49.34	341	35	36.51	[illegible]
Silliman	357	42	48.51	177	43	37.67	4.707654

HILGARD, FRESNO COUNTY, CAL.

Ascended from camp on Bear Creek, five and one-half hours' travel. Could camp an hour closer by going to summit of ridge between Bear and Mono creeks. Best approached along ridge between Bear and Mono creeks, finally dropping down into northeast fork of Bear Creek and climbing peak from east. On summit of this peak are three small high points of rock. The north or center one is point occupied.

Station mark: A large flat rock, in which is cemented a bronze triangulation tablet, surmounted by a cairn 3 feet in diameter at base and 3 feet high.

[Latitude 37° 21′ 39.44″. Longitude 118° 49′ 34.10″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Three Sisters	40	31	27.33	220	22	57.41	[illegible]
Silver	125	09	54.14	305	02	48.66	[illegible]
Goddard	341	36	11.21	161	40	04.09	[illegible]
Kaiser	77	03	50.04	256	50	47.29	4.513451
Big Shuteye	88	51	40.06	268	29	47.16	[illegible]

KAISER, FRESNO COUNTY, CAL.

On a bald peak at the head of Kaiser and Pittman creeks, easily ascended from the south side. There are numerous lakes and small meadows in the neighborhood.

Station mark: A bronze triangulation tablet set in loose earth, there being no solid rock, above which was erected a cairn 5 feet in diameter at base and 5 feet high.

[Latitude 37° 17′ 40.52″. Longtiude 119° 11′ 05.66″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Lyell	171	16	36.00	351	13	27.41	4.6988733
Silver	216	42	52.26	36	48	51.25	4.3856890
Goddard	297	01	25.41	117	18	18.97	4.6671675
Three Sisters	326	51	14.47	146	55	46.14	4.3069355
Big Shuteye	106	00	18.72	285	51	29.47	4.3493243
Red	153	40	16.75	333	32	06.49	4.6487072
Lyell	171	16	30.07	351	13	21.55	4.6982751
Silver	216	42	50.78	36	48	49.60	4.3855104
Hilgard	256	50	47.29	77	03	50.04	4.5135451

HUMPHREYS, FRESNO AND INYO COUNTIES, CAL.

(Not occupied.)

On the highest point of Mount Humphrey, a very prominent mountain on the main crest of the Sierras, between the North Palisade and Hilgard, and at the source of Mill Creek, a tributary of Owens River. There is a trail up Mill Creek to foot of mountain.

Station mark: Highest point, a very sharp peak.

[Latitude 37° 16′ 15.12″. Longitude 118° 40′ 20.38″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Goddard	12	38	27.03	192	36	55.00	4.2797563
Three Sisters	67	29	24.74	247	15	20.53	4.5716837
Morgan	160	28	16.60	340	26	05.80	4.2004826
Split Mountain	321	08	50.51	141	17	55.11	4.5506914

RED SLATE, FRESNO AND MONO COUNTIES, CAL.

(Not occupied.)

This point is a high, round-topped mountain on the main crest of the Sierras. Highest point between Mono Pass and Mammoth Pass.

Station mark: Highest point.

[Latitude 37° 30′ 28.37″. Longitude 118° 52′ 07.16″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Silver	72	41	27.42	252	35	54.39	4.1487274
Lyell	126	03	00.98	305	48	17.83	4.6420540
Baldy	205	30	18.28	25	36	12.72	4.5171594
Morgan	313	12	06.38	133	17	05.06	4.2193242

SPLIT MOUNTAIN, FRESNO AND INYO COUNTIES, CAL.

On highest point of Split Mountain, which is on crest of the Sierras at the source of Tinnemaha Creek, flowing into Owens River, and Cartridge Creek, flowing into middle fork of Kings River. There is a higher point about 8 miles northwest (Mount Jordan). The point can be easily reached from the west side by going up Cartridge Creek to the summit of the ridge, thence south to peak. It can also be reached from the head of Tinnemaha Creek. It would be very difficult to climb it from the south.

Station mark: A cairn 6 feet high on highest point.

[Latitude 37° 01′ 16.40″. Longitude 118° 25′ 18.51″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Brewer	9	11	54.05	189	09	38.34	4.5455577
Goddard	109	06	57.48	288	56	12.20	4.4[illegible]10
Morgan	147	13	59.01	327	02	43.14	4.7057155
White Mountain, south	192	12	05.44	12	18	09.46	4.8[illegible]52
Black Mountain	212	37	23.61	32	44	32.20	4.5110832
Waucoba	269	42	52.99	89	57	51.70	4.5[illegible]785
Keynot	310	08	55.38	130	25	29.22	4.7[illegible]221
Whitney	346	36	56.01	166	41	37.36	4.7028133

SILVER, FRESNO COUNTY, CAL.

On the highest peak between Fish and Mono creeks, at head of Silver Creek. Summit is flat, running north-northeast and south-southwest. Highest point is at southwest end. Can camp at meadows below Margaret Lakes. Thence it is three and one-half hours' travel to station. Can take mules within 700 feet of summit on east. There is grass and water for one night within 1,200 feet of summit.

Station mark: A bronze triangulation tablet set in solid rock, on which was erected a cairn of rocks 5 feet in diameter at base and 5 feet high.

[Latitude 37° 28′ 12.09″. Longitude 119° 01′ 14.36″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Big Shuteye	69	48	41.16	249	33	51.80	4.5842389
Red	120	54	43.33	300	40	31.80	4.6010821
Lyell	143	38	27.25	323	29	17.71	4.570[illegible]63
Hillgard	305	02	47.29	125	09	52.52	4.3230108
Three Sisters	5	29	49.98	185	28	23.83	4.5637232
Kaiser	36	48	51.25	216	42	52.26	4.3856891
Lyell	143	38	30.57	323	29	20.79	4.5706540
Morgan	285	33	44.39	105	44	15.58	4.4233811
Goddard	326	36	13.95	146	47	11.35	4.6873652

BIG PINE, INYO COUNTY, CAL.

(Not occupied.)

Station mark: The cupola on school in Big Pine.

[Latitude 37° 09′ 57.91″. Longitude 118° 17′ 35.59″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Split Mountain	35	34	20.99	215	29	40.59	4.2956901
Round	110	29	24.80	290	24	21.19	4.1213363
Black Mountain	208	14	55.26	28	17	23.37	4.1054372

BISHOP, INYO COUNTY, CAL.

Station mark: The cupola on Methodist Academy in Bishop.

[Latitude 37° 21′ 48.29″. Longitude 118° 23′ 53.11″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Morgan	95	05	26.58	278	53	16.21	4.4765596
Sheep	221	11	34.11	41	18	09.84	4.3849933
Black Mountain	304	42	42.28	124	49	00.79	4.2722012

BLACK MOUNTAIN, INYO COUNTY, CAL.

On the highest point of Black Mountain, a comparatively low mountain on the east side of Owens Valley between Black Canyon on the north and the toll road on the south, about 15 miles southeast of Bishop and 12 miles northeast of Big Pine. Animals can be taken to summit from south, though it is rather steep. There is a trail up Black Canyon to an abandoned mine three-fourths of a mile from station. Collin's residence is near mouth of Black Canyon.

Station mark: A rock cairn 6 feet in diameter at base and 8 or 9 feet high, with tree in center; triangulation tablet under center of tree.

[Latitude 37° 16′ 02.12″. Longitude 118° 13′ 28.72″.]

To station—	Azimutn.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Split Mountain	32	44	32.20	212	37	23.61	4.5110832
Round	70	19	33.80	250	12	01.66	4.2915272
Morgan	108	59	56.83	288	41	28.57	4.6769728
Heckla	140	17	52.94	320	06	20.01	4.6526073
White Mountain South	176	13	52.81	356	12	46.23	4.6111148
Sheep	181	17	14.31	1	17	30.38	4.4612513
Piper	239	00	19.49	59	11	08.24	4.4869603
Blue Dick	244	30	31.69	64	53	38.05	4.7932844
White Top	268	00	08.56	88	19	14.31	4.6687104
Gold Mountain	270	52	06.99	91	25	31.52	4.9117079
Waucoba	324	33	01.22	144	40	53.89	4.5232682

CRATER, INYO COUNTY, CAL.

On a small red hill with crater in center, between Tinnemaha and Taboose creeks and west of the road between Independence and Big Pine. Animals can be ridden to summit.

Station mark: A cairn about 5 feet high

[Latitude 37° 01′ 45.14″. Longitude 118° 17′ 15.83″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Split Mountain	85	47	37.70	265	42	47.05	4.0778684
Round	147	05	42.24	327	00	28.39	4.3730474
Black Mountain	191	57	31.68	11	59	48.83	4.4314636
Independence	342	27	37.89	162	30	49.50	4.4189681

DARWIN, INYO COUNTY, CAL.

(Not occupied.)

[Latitude 37° 10′ 01.88″. Longitude 118° 40′ 17.34″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Three Sisters	85	24	33.45	265	10	28.40	4.5396108
Silver	137	27	48.71	317	15	06.64	4.6598175
Morgan	168	30	32.81	348	28	21.32	4.4313845

DOUBLE, INYO COUNTY, CAL.

(Not occupied.)

This is a very prominent peak, and the highest point was located.

[Latitude 37° 33′ 39.21″. Longitude 118° 54′ 23.76″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Silver	45	01	54.44	224	57	44.39	4.1541539
Baldy	216	18	56.03	36	26	14.12	4.4706843
Morgan	318	07	30.59	138	13	52.56	4.3641389

INDEPENDENCE, INYO COUNTY, CAL.

Station mark: The cupola on court-house in Independence.

[Latitude 36° 48′ 13.33″. Longitude 118° 11′ 56.80″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Williamson	31	20	30.42	211	16	30.48	4.2823466
Crater	162	30	49.50	342	27	37.89	4.4189681
Keynot	296	34	50.74	116	43	22.33	4.3752495

KEYNOT, INYO COUNTY, CAL.

On highest point of mountain on east side of Owens Valley, about 16 or 18 miles northeast of Lone Pine post-office, by road and trail. The trail from Lone Pine to Keynot mine crosses ridge about 2 miles south of point. Animals can be taken to signal.

Station mark: A rock cairn 8 feet high with tree in center.

[Latitude 36° 42′ 28.02″. Longitude 117° 57′ 41.90″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Olancha	15	55	49.03	195	50	15.38	4.7078290
Whitney	64	13	37.07	244	01	48.67	4.5154617
Williamson	79	42	21.24	259	29	50.89	4.5011643
Split Mountain	130	25	29.22	310	08	55.38	4.7307221
Waucoba	173	22	19.33	353	20	40.94	4.5455821

MORGAN, INYO COUNTY, CAL.

On highest part of high mountain, on east side and near source of Rock Creek. A rock cairn was found on this mountain, probably of Wheeler Survey in 1878. There is a trail from J. L. C. Sherwin's ranch in Round Valley to source of Rock Creek. Another trail goes from same place to Rickey's ranch in Long Valley, and trail up Mono Creek crosses range and intersects above-mentioned trails. This is the only mountain in the vicinity visible from Conness. Cairn was in good condition and was not disturbed.

Station mark: Triangulation tablet cemented in large flat rock, distant 10.2 feet, azimuth 72° 33′, from cairn of Wheeler Survey.

[Latitude 37° 24′ 20.14″. Longitude 118° 43′ 56.04″.]

To station—	Azimuth.			Back azimuth			Log. distance.
	°	′	″	°	′	″	*Meters.*
Three Sisters	44	53	05.52	224	41	10.61	4.6157891
Silver	105	44	15.58	285	33	44.39	4.4233811
Lyell	128	05	41.28	307	45	58.78	4.7805563
Conness	140	24	24.56	320	02	49.62	4.9091556
Baldy	182	59	48.38	3	00	41.92	4.6136960
White Mountain, north	214	29	18.27	34	43	04.27	4.7666392
Heckla	220	03	25.98	40	10	06.14	4.3991161
White Mountain, south	238	48	03.66	59	05	29.89	4.6923306
Black Mountain	288	41	28.57	108	59	56.83	4.6760728
Waucoba	303	15	12.77	123	41	31.37	4.8873537
Round	309	27	08.48	129	38	03.12	4.5377405
Split Mountain	327	02	43.14	147	13	59.01	4.7057157
Sheep	253	15	49.17	73	34	36.83	4.6769802
Goddard	358	01	28.67	178	01	57.03	4.5257589

OLANCHA, INYO AND TULARE COUNTIES, CAL.

Highest peak on range southwest of Owens Lake. Can be easily ascended from the Monache Meadows on South Fork of Kern River. Animals can be ridden almost to timber line; thence very good walking to summit. Point was used by Wheeler Survey, as a small rock cairn was found on highest point.

Signal: Rock cairn 7 feet in diameter at base and 10 feet high was erected at same point.

Station mark: A triangulation tablet cemented in rock at center of cairn.

[Latitude 36° 15′ 55.67″. Longitude 118° 07′ 03.00″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	Meters.
Mahogany	24	12	42.16	204	07	53.77	4.475084
Big Meadows	27	10	05.78	207	02	29.90	4.652480
Kern	107	33	43.41	287	27	41.77	4.203836
Florence	112	03	14.31	291	47	51.25	4.622041
Kaweah Mountain	131	57	46.73	311	44	57.01	4.637102
Whitney	155	54	30.34	335	48	18.76	4.581321
Keynot	195	50	15.38	15	55	49.03	4.707890
Sunday	38	16	38.85	218	00	10.70	4.832965

PALISADE, FRESNO AND INYO COUNTIES, CAL.

(Not occupied.)

North Palisade, or Mount Jordan, divides the waters of Big Pine Creek and Palisade Creek, the former flowing into Owens River, the latter into Middle Fork of Kings River. Highest point north of Split Mountain and probably higher than latter. Very difficult to climb. Best reached up Palisade Creek.

Station mark: Highest point on mountain.

[Latitude 37° 05′ 40.45″. Longitude 118° 30′ 49.68″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	Meters.
Goddard	93	08	26.77	273	01	00.70	4.362146
Morgan	150	45	15.18	330	37	19.20	4.597535
Round	209	58	09.31	30	01	06.71	4.161346
Split Mountain	314	49	29.21	134	52	48.78	4.0822[illegible]

PINCHOT, FRESNO AND INYO COUNTIES, CAL.

A round-topt red mountain about 8 miles down (south) the main crest of the Sierras from Split Mountain, and probably the highest point between the Kearsarge Pass and Split Mountain. It is also called Red Mountain.

Station mark: The highest point of mountain.

[Latitude 36° 56′ 51.75′. Longitude 118° 24′ 17.21″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	Meters.
Split Mountain	169	28	42.71	349	28	05.83	3.9159[illegible]
Waucoba	256	44	35.37	76	58	56.45	4.580[illegible]
Keynot	303	49	32.80	124	05	29.04	4.678[illegible]
Whitney	346	03	52.24	166	07	56.65	4.624[illegible]

PIPER, INYO COUNTY, CAL.

On highest point of range of low mountains between Fish Valley and Deep Spring Valley, on the east side and about 1 mile distant from road between Big Pine and Oasis and about 7 miles from latter. Animals can be taken within a short distance of summit.

Station mark: A triangulation tablet cemented in rock under center of cairn 9 feet high.

[Latitude 37° 24′ 33.39″. Longitude 117° 55′ 39.06″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Waucoba	9	22	19.54	189	19	26.05	4.6388914
Black Mountain	59	11	08.24	239	00	19.49	4.4869603
Sheep	117	15	12.24	297	04	37.65	4.4595886
White Mountain South	130	53	56.41	310	41	58.24	4.5826240
Boundary post 74	205	33	23.55	25	35	17.27	4.0275048
Boundary post 75	228	20	26.76	48	23	35.98	4.0101962
Blue Dick	250	00	44.76	70	13	03.73	4.5013097
Magruder	269	36	21.55	89	50	15.96	4.5276844
White Top	305	06	30.66	125	14	49.43	4.3937678

ROUND, INYO COUNTY, CAL.

On a round, bald point about 10 miles west-northwest of Big Pine and on east side of Coyote Valley. A trail goes from Big Pine up Baker Creek to Coyote Valley. Animals can be ridden to summit.

Station mark: A cairn about 7 feet high, 122 feet south of highest point of mountain. Cairn is probably a corner on forest, reserve line and was not disturbed.

[Latitude 37° 12′ 27.77″. Longitude 118° 25′ 55.91″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Morgan	129	38	03.12	309	27	08.48	4.5377405
Black Mountain	250	12	01.66	70	19	33.80	4.2915272
Waucoba	298	28	08.81	118	43	32.04	4.6336966
Split Mountain	357	26	31.89	177	26	54.46	4.3163237

SHEEP, INYO COUNTY, CAL.

On the highest point of southeasternmost of two high red peaks at the source of Piute Creek. Can be reached by same trail that goes to White Mountain South station, except that one travels south after reaching summit of ridge.

Station mark: A triangulation tablet set in loose rock under center of a cairn 7 feet high.

[Latitude 37° 31′ 40.09″. Longitude 118° 13′ 02.25″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Black Mountain	1	17	30.38	181	17	14.31	4.4612513
Bishop	41	18	09.84	221	11	34.11	4.3849933
Morgan	73	34	36.83	253	15	49.17	4.6769802
White Mountain South	164	16	27.53	344	15	04.62	4.0898619
Piper	297	04	37.65	117	15	12.24	4.4595886

TOM, INYO COUNTY, CAL.

(Not occupied.)

On the highest point of Mount Tom, a well-known mountain on the west side of Round Valley; not difficult to climb.

Station mark: A small cairn.

[Latitude 37° 20′ 19.70″. Longitude 118° 39′ 23.01″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Three Sisters	58	41	50.70	238	27	11.11	4.62307
Morgan	137	50	13.72	317	47	28.00	4.00015
White Mountain South	227	07	33.67	47	22	15.39	4.6842

WAUCOBA, INYO COUNTY, CAL.

On highest point in range of mountains about 20 miles northeast of Independence. There is a wagon road from Citrus up Mazurka Canyon to its head, thence by trail about 2 miles east to a spring, which is only water in vicinity. The mountain can be seen northeast from ridge where trail crosses just before going down to spring, but signal is not in view. Station is 3 miles from spring and can be reached on horseback. There is little grass, but by letting animals range north and east they can get along fairly well.

Station mark: A cairn 12 feet high. All trees were cut or burned from summit of the mountain.

[Latitude 37° 01′ 19.76″. Longitude 118° 00′ 25.90″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters*
Whitney	27	21	35.89	207	11	23.12	4.7432
Williamson	33	46	05.70	213	35	10.92	4.6884
Split Mountain	89	57	51.70	269	42	52.99	4.56697
Round	118	43	32.04	298	28	08.81	4.63365
Morgan	123	41	31.37	303	15	12.77	4.88735
Black Mountain	144	40	53.89	324	33	01.22	4.52326
White Mountain South	162	09	37.92	342	00	36.84	4.85380
Piper	189	19	26.05	9	22	19.54	4.63880
Montezuma	217	16	02.41	37	39	33.03	4.97338
White Top	223	33	00.76	43	44	10.54	4.598304
Gold Mountain	247	30	26.42	67	55	52.73	4.828872
Keynot	353	20	40.94	173	22	19.33	4.54558

THREE SISTERS, FRESNO COUNTY, CAL.

On the south end of summit of the Three Sisters. Can be reached by trail between Shaver and Blaney Meadow (or Hot Springs). Leave trail at large meadow between Red Mountain and Potato Hill, traveling southeast. At foot of mountain on northeast side is a small meadow with running water. Animals can be taken nearly to summit from south to southeast.

Station mark: A bronze triangulation tablet set in loose rock with a cairn built over it 3 feet in diameter at base and 3 feet high.

[Latitude 37° 08′ 29.64″. Longitude 119° 03′ 36.50″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Kaiser	146	55	46.14	326	51	14.47	4.3069355
Silver	185	28	23.83	5	29	49.98	4.5637231
Morgan	224	41	10.61	44	53	05.52	4.6157891
Goddard	277	51	05.29	98	03	25.99	4.4856065
Big Shuteye	125	27	35.30	305	14	15.24	4.6014723
Silliman	329	28	41.38	149	41	47.00	4.8062703
Spanish (preliminary)	329	37	29.39	149	43	36.33	4.4747072
Baldy	342	58	38.44	163	05	03.75	4.7358215

WHITE TOP, INYO COUNTY, CAL.

On summit of white-topped mountain about 6 miles up ridge (southeast) from Last Chance Mountain. The nearest water is at Willow, which is 7½ miles from Pigeon Springs, a well-known point on the Oasis-Lida road. There is no forage in the country; a wagon can be taken to Willow Spring, and animals can be ridden from that place to summit by going up ridge and keeping on the divide.

Station mark: A triangulation tablet set in loose rock under center of cairn 6 feet high.

[Latitude 37° 16′ 50.65″. Longitude 117° 41′ 56.80″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Waucoba	43	44	10.54	223	33	00.76	4.5983045
Black Mountain	88	19	14.31	268	00	08.56	4.6687104
Piper	125	14	49.43	305	06	30.66	4.3937678
White Mountain South	128	45	45.34	308	25	28.17	4.7988824
Blue Dick	200	59	12.38	21	03	10.06	4.4287747
Magruder	223	02	13.54	43	07	46.12	4.2956894
Gold Mountain	274	59	44.33	95	14	03.60	4.5453611

WHITNEY, TULARE AND INYO COUNTIES, CAL.

Station is on the highest point of Mount Whitney. Peak is at source of Crabtree Creek as given by old Sierra Club map (but Whitney Creek on most recent edition) and Lone Pine Creek. Whitney Creek flows into Kern River. There is a good trail from Lone Pine post-office to summit of peak and another trail from Kern River up old Whitney or Volcano Creek to its source, thence over ridge to Rock Creek, thence over ridge to Whitney Creek, thence up creek to foot of mountain. Elevation, 14,499 feet above mean sea level.

Station mark: A triangulation tablet cemented in rock under center of a cairn 8 feet high.

[Latitude 36° 44′ 44.14″. Longitude 118° 17′ 28.84″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Big Meadows	2	55	30.58	182	54	03.07	4.8615178
Florence	50	32	40.95	230	23	26.66	4.4782336
Kaweah Mountain	70	49	52.86	250	43	13.01	4.2475638
Brewer	129	52	34.57	309	45	39.25	4.3522874
Goddard	146	52	26.30	326	37	02.71	4.8426164
Split Mountain	166	41	37.36	346	36	56.01	4.7028113
Williamson	168	40	29.09	348	39	47.84	3.9418286
Waucoba	207	11	23.12	27	21	35.89	4.7430219
Keynot	244	01	48.67	54	13	37.07	4.5154617
Olancha	335	48	18.76	155	54	30.34	4.5811231
Kern	359	17	41.07	179	17	49.85	4.4767457

WILLIAMSON, TULARE AND INYO COUNTIES, CAL.

(Not occupied.)

On the highest point of Mount Williamson, a well-known mountain about 5 miles a little west of north from Mount Whitney. The mountain can be climbed from either side, but animals can not be taken to summit.

Station mark: The higher of two cairns.

[Latitude 36° 39′ 22.35″. Longitude 118° 18′ 37.99″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Split Mountain	166	16	00.70	346	12	00.57	4.6301792
Waucoba	213	35	10.92	33	46	05.70	4.6884122
Keynot	259	29	50.89	79	42	21.24	4.5011843
Whitney	348	39	47.84	168	40	29.09	3.9418286

BALDY, MONO COUNTY, CAL.

On the northwestern of two high points on mountain locally known as Baldy, almost 10 miles a little south of west of Benton post-office and store, on east side of Long Valley. It can be reached by road and trail either from Benton or Long Valley. This is the highest point in the range between the Sierras and White Mountains and probably about 10,000 feet above sea. Animals can be taken to summit.

Station mark: A cairn 6 feet in diameter at base and 8 feet high, with tree in center and triangulation tablet cemented in rock under center of tree.

[Latitude 37° 46′ 31″.00 Longitude 118° 42′ 28.27″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Morgan	3	00	41.92	182	59	48.38	4.6138940
Lyell	85	37	47.22	265	17	06.03	4.6970120
Conness	111	45	56.12	291	23	22.03	4.7633985
Horse	158	41	58.00	338	38	15.64	4.3861824
White Mountain North	257	02	05.63	77	15	01.28	4.5017243
White Mountain South	291	14	13.31	111	30	50.25	4.6322517
Heckla	327	23	11.08	147	28	59.28	4.4139048

CASTLE PEAK, MONO COUNTY, CAL.

(Not occupied.)

A high mountain north of Conness.

Station mark: A small cairn.

[Latitude 38° 03′ 53.91″. Longitude 119° 16′ 25.04″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Horse	282	56	07.78	103	13	19.27	4.6225526
Baldy	302	42	08.89	123	03	00.60	4.7725734
Conness	20	52	19.21	200	50	35.01	4.0641384

HORSE, MONO COUNTY, CAL.

On the highest point of a sagebrush ridge about 5 miles east of Mono Lake and about 10 miles north-northwest of Dexter Meadows, on road between Benton and Crater Lake post-office. There is no feed nor water closer than Dexter Meadows. A small spring about 3 miles south, but not sufficient water for camp. Animals can be ridden anywhere in this country.

Station mark: A triangulation tablet cemented in rock under center of cairn 9 feet high.

[Latitude 37° 58′ 46.14″. Longitude 118° 48′ 50.44″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Lyell	56	57	56.53	236	40	54.76	4.6868437
Conness	88	26	54.14	268	07	59.79	4.6534201
White Mountain North	291	17	08.39	111	33	48.34	4.6305132
Baldy	338	38	15.64	158	41	58.00	4.3861824

HECKLA, MONO COUNTY, CAL.

On a high rocky hill (not mountain), about 20 miles northwest of Bishop. There are a great many mines or prospects in the hill, several of which are owned by J. L. C. Sherwin. Road from Bishop to Long Valley passes about 2 miles south of point where first timber is reached; thence there are several wood roads to foot of hill. Animals can be taken within 200 feet of point on northwest side, but thence up it is very rough. No available water or food near. Owens River is not more than 6 miles south, but it is difficult to get down to water.

Station mark: A triangulation tablet cemented under rock under center of tree, with small cairn around it on highest rock on hill.

[Latitude 37° 34′ 42″.00 Longitude 118° 32′ 58.58″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Morgan	40	10	06.14	220	03	25.98	4.3991161
Baldy	147	28	59.28	327	23	11.08	4.4139048
White Mountain South	256	26	26.69	76	37	13.77	4.4272420
Black Mountain	320	06	02.01	140	17	52.94	4.6526073

LYELL, MONO COUNTY, CAL.

At end of Tuolumne Meadows, 14 miles southeast of Soda Springs. The south side a nearly perpendicular wall, the north a series of meadows until glacier is reached; the east and west sides rather steep. The highest point is a short sharp ridge, about 200 yards long, running northwest and southeast, the northwest end being the lower. Ascended from head of Lyell Fork and northeast side of peak.

Station mark: Small stone monument; "U.S.G.S." chiseled on rock east of it.

[Latitude 37° 44′ 23.13″. Longitude 119° 16′ 15.30″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Conness	170 11 34.84	350 09 45.17	4.4089271
Horse	236 40 54.76	56 57 56.53	4.6866437
Baldy	265 17 06.03	85 37 47.22	4.6970120
White Mountain South	277 07 12.03	97 44 27.83	4.9559946
Morgan	307 45 58.78	128 05 41.28	4.7805563
Silver	323 29 20.79	143 38 30.57	4.5706562
Kaiser	351 13 27.41	171 16 36.00	4.6968733
Big Shuteye	17 46 48.27	197 41 04.96	4.6571504
Red	52 03 35.82	231 58 32.37	4.1582294
Clarks Peak	71 03 13.41	250 57 27.71	4.1654618
Hoffman	119 37 00.01	299 28 12.89	4.3836744
Dana	193 59 22.02	14 01 13.38	4.2637680

MONO, MONO COUNTY, CAL.

(Not occupied.)

Station mark: The highest point of Crater Mountain, near Crater post-office.

[Latitude 37° 52′ 42.26″. Longitude 119° 00′ 23.41″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Conness	109 46 14.98	289 34 40.11	4.4673460
Horse	237 08 41.29	57 15 59.54	4.3162328
Baldy	293 26 00.44	113 36 59.80	4.4575319

MONUMENT, MONO COUNTY, CAL.

(Not occupied.)

[Latitude 37° 48′ 09.48″. Longitude 118° 20′ 41.20″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Baldy	84 41 17.11	264 27 56.20	4.5068484
White Mountain North	165 48 16.54	345 47 50.95	3.6186534
White Mountain South	337 00 13.44	157 03 31.05	4.3089023

WHITE MOUNTAIN NORTH, MONO COUNTY, CAL.

A point located by the Coast and Geodetic Survey and also occupied by the Wheeler Survey. No signal was found in 1905, except a small pile of rocks, probably left by members of the Wheeler Survey.

Station mark: A large cairn erected over small rock pile of Wheeler Survey.

[Latitude 37° 50′ 20.15″. Longitude 118° 21′ 22.95″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Morgan	34	43	04.27	214	29	18.27	4.7066392
Baldy	77	15	01.28	257	02	05.63	4.5017243
Conness	99	50	21.87	279	14	49.46	4.9344715
Horse	111	33	48.34	291	17	08.39	4.6305132
White Mountain South	338	29	12.76	158	32	56.00	4.3871739
Mount Grant	155	02	03.90	334	45	56.70	4.9527523
Carson Sink	183	05	17.80	3	09	51.60	5.2876628
Toiyabe Dome	218	11	31.10	38	48	52.90	5.1492056
Lone Mountain	254	31	38.60	75	03	27.40	4.8953334
White Pine	257	05	50.50	78	51	30.30	5.4084214

WHITE MOUNTAIN SOUTH, MONO COUNTY, CAL.

A point located by the Coast and Geodetic Survey on the highest summit of the White Mountain Range. It is best reached from Bishop by following the wagon road to Kellogg's ranch, a distance of 10 or 12 miles, thence along trail up Piute Creek to a cabin at end of old wagon road, thence up a creek 0.25 mile, thence along trail up the ridge nearly to summit of peak.

Station mark: A cairn 13 feet in diameter at base and 13 feet high.

[Latitude 37° 38′ 04.07″. Longitude 118° 15′ 18.20″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Split Mountain	12	18	09.46	192	12	05.44	4.8428852
Morgan	59	05	29.89	238	48	03.66	4.6923306
Heckla	76	37	13.77	256	26	26.69	4.4272420
Lyell	97	44	27.83	277	07	12.03	4.9559946
Baldy	111	30	50.25	291	14	13.31	4.6322517
Conness	111	49	04.10	291	09	53.00	5.0037076
White Mountain North	158	32	56.00	338	29	12.76	4.3871739
Montezuma	264	52	07.86	85	24	53.55	4.8983360
Blue Dick	283	23	45.73	103	48	04.67	4.7811244
Gold Mountain	296	27	53.08	117	02	32.64	4.9738652
White Top	308	25	28.17	128	45	45.34	4.5826240
Piper	310	41	58.24	130	53	56.41	4.5826240
Waucoba	342	00	36.84	162	09	37.92	4.8538027
Black Mountain	356	12	46.23	176	13	52.81	4.6111148
Carson Sink	180	29	43.90	0	28	29.60	4.8157908
Toiyabe Dome	210	26	05.50	30	59	36.70	5.1895998
Lone Mountain	236	53	48.40	57	21	49.20	4.9019728
White Pine	251	42	23.40	73	24	04.40	5.4041605

BIG MEADOWS, TULARE COUNTY, CAL.

The highest point on range between Kern River and South Fork of Kern River, about 25 miles northeast of Kernville along the Mount Whitney trail.

Station mark: A bronze triangulation tablet cemented in a large bowlder, over which is erected a cairn 6 feet high.

[Latitude 35° 55′ 28.61″. Longitude 118° 19′ 56.81″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Florence	159	55	59.35	339	48	16.67	4.7553965
Whitney	182	54	03.07	2	55	30.58	4.8615178
Kern	185	26	27.52	5	28	03.46	4.6317012
Olancha	207	02	29.90	27	10	05.78	4.6282480
Mahogany	213	58	12.72	34	01	00.04	4.1060172
Pahute	5	46	09.34	185	44	06.62	4.7224576
Breckinridge	23	25	23.77	203	16	37.60	4.7575660
Sunday	55	21	15.81	235	12	24.95	4.4420184
Moses	141	33	04.62	321	20	46.63	4.7013414

BREWER, TULARE COUNTY, CAL.

Highest point of Mount Brewer, a prominent mountain at source of Brewer Creek; rather difficult to climb. Sharp peak at summit is used for signal.

Station mark: A cairn.

[Latitude 36° 42′ 31.67″. Longitude 118° 29′ 04.70″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	″	′	°	″	′	*Meters.*
Goddard	154	33	01.05	334	24	33.96	4.6859822
Split Mountain	189	09	38.34	9	11	54.05	4.5455577
Whitney	309	45	39.25	129	52	34.57	4.3522874
Kaweah Mountain	358	16	31.93	178	16	46.53	4.3062797

FLORENCE, TULARE COUNTY, CAL.

Mount Florence is the highest point east of Farewell Gap, about 6 miles southeast of Mineral King, at headwaters of Middle Fork of Kaweah and Little Kern rivers.

Station mark: A bronze triangulation tablet cemented in solid rock, surmounted by a cairn 6 feet high.

[Latitude 36° 24′ 23.05″. Longitude 118° 33′ 00.85″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Kaweah Mountain	205	57	00.40	25	59	35.31	4.1708006
Whitney	230	23	26.66	50	32	40.95	4.4782336
Olancha	291	47	51.25	112	03	14.31	4.6230191
Kern	294	33	40.96	114	43	02.25	4.4144867
Mahogany	328	00	03.75	148	10	35.24	4.7033678
Big Meadows	339	48	16.67	159	55	59.35	4.7553965
Sunday	2	32	31.46	182	31	19.39	4.8406527
Moses	39	35	55.38	219	31	17.76	4.2635024
Baldy	134	54	42.41	314	42	51.70	4.6217913
Silliman	153	37	10.01	333	31	56.75	4.4687506

KAWEAH MOUNTAIN, TULARE COUNTY, CAL.

On easternmost and only flat-topped mountain of the Kaweah group. At the source of Chagoopa Creek, a tributary of Kern River. Best reached by Chagoopa Creek.

Station mark: A small cairn, on highest point of mountain.

[Latitude 36° 31′ 35.24″. Longitude 118° 28′ 40.21″.]

To station.	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Florence	25	59	35.31	205	57	00.40	4.1708006
Brewer	178	16	46.53	358	16	31.93	4.3062797
Whitney	250	43	13.01	70	49	52.86	4.2475638
Olancha	311	44	57.01	131	57	46.73	4.6375102
Kern	324	38	58.74	144	45	46.09	4.4711073

KERN, TULARE COUNTY, CAL.

On high, rocky mountain on divide between Kern River and South Fork of Kern River. The range is sometimes called Too-wa Range; it is about 4 miles south of the Mount Whitney trail at point where tunnel was cut from Whitney Creek to South Fork of Kern River. The trail down South Fork of Kern River to Monache Meadows passes within about 3 miles of station and signal can be seen from meadow after leaving Whitney Creek. Animals can be taken within 500 feet of summit.

Station mark: A triangulation tablet set in solid rock under center of cairn, on highest point of mountain.

[Latitude 36° 18′ 31.77″. Longitude 118° 17′ 14.05″.]

To station.	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Big Meadows	5	28	03.46	185	26	27.52	4.6317012
Florence	114	43	02.25	294	33	40.96	4.4144807
Kaweah Mountain	144	45	46.09	324	38	58.74	4.4711073
Whitney	179	17	49.85	359	17	41.07	4.4767457
Olancha	287	27	41.77	107	33	43.41	4.2038386
Mahogany	354	33	04.26	174	34	16.30	4.5077615

MAHOGANY, TULARE COUNTY, CAL.

On a spur of Big Meadows Mountain and on divide of the waters of Fish Creek and South Fork of Kern River. The Kernville-Mount Whitney trail passes about 1 mile west of station on ridge. Can be reached by trail from the Monache Meadows. The summit has scattering clusters of mahogany trees on it. Animals can be taken to the signal. Description of trail is difficult, as there are many cattle trails in all directions. Fish Creek meadow is nearest good one.

Station mark: A triangulation tablet under center of a rock cairn 6 feet in diameter at base and 5.8 feet high, with a tree in center.

[Latitude 36° 01′ 11.99″. Longitude 118° 15′ 11.97″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Big Meadows	34	01	00.04	213	58	12.72	4.1060172
Florence	148	10	35.24	328	00	03.75	4.7033678
Kern	174	34	16.30	354	33	04.26	4.5077615
Olancha	204	07	53.77	24	12	42.16	4.4750064

TRAIL, TULARE COUNTY, CAL.

(Not occupied.)

Summit of mountain at end of high Sierras. The trail that goes up South Fork of Kern River thru Mulkey Meadows, thence across main ridge and down Cottonwood Creek to Lone Pine, passes south of and within a mile of point at summit of ridge. Can camp on either side of ridge.

Station mark: Highest point of mountain.

[Latitude 36° 25′ 39.77″. Longitude 118° 11′ 22.97″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Kern	33	35	24.09	213	31	55.91	4.1995225
Florence	85	55	26.10	265	42	35.60	4.5108296
Whitney	151	32	41.44	331	29	03.80	4.2806189

CONNESS, TUOLUMNE COUNTY, CAL.

A primary station of the Coast and Geodetic Survey, 10 miles north of Soda Springs. In shape an irregular parallelogram of granite, from northwest portion of which rises the top of peak, with precipitous side of 1,000 feet or more. It can be ascended from Soda Springs in four hours by a trail made by the Coast and Geodetic Survey. Grass and water can be found within 1 mile of summit.

Station mark: Concrete pier, with ⅝-inch copper bolt in center.

[Latitude 37° 58′ 02.59″. Longitude 119° 19′ 14.23″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Red	12	36	41.02	192	33	26.59	4.55157670
Clarks Peak	17	29	05.74	197	25	09.01	4.49796440
Devil Peak	37	22	32.54	217	07	08.88	4.78554630
Hoffman	51	21	09.23	231	14	10.79	4.32883400
Cottonwood Peak	83	06	44.80	262	51	29.07	4.56390410
Dana	310	11	57.93	130	15	39.67	4.08213700
Round Top	142	39	27.37	322	14	10.26	4.98913744
Mount Grant	214	32	19.16	34	52	00.68	4.91090086
Castle Peak	200	50	35.01	20	52	19.21	4.06413840
Horse	268	07	59.79	88	26	54.14	4.65342010
White Mountain South	291	09	53.00	111	49	04.10	5.00370700
Baldy	291	23	22.03	111	45	56.12	4.76336850
Morgan	320	02	49.62	140	24	24.56	4.90915300
Lyell	350	09	45.17	170	11	34.84	4.40882710

CALIFORNIA-NEVADA BOUNDARY POST TRIANGULATION STATION NO. 75.

Position computed was that of the old triangulation station near No. 75.

[Latitude 37° 28′ 14.01″. Longitude 117° 50′ 27.80″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Piper	48	23	35.98	228	20	26.76	4.0101962
White Mountain South	116	33	54.60	296	18	46.22	4.6112609
Boundary post 74	132	35	01.54	312	33	45.93	3.6175456

CALIFORNIA-NEVADA BOUNDARY POST TRIANGULATION STATION NO. 74.

Position computed was that of the old triangulation station near No. 74.

[Latitude 37° 29′ 44.97″. Longitude 117° 52′ 32.05″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Piper	25	35	17.27	205	33	23.55	4.0273048
White Mountain South	114	46	02.30	294	32	09.41	4.5669083
Boundary post 75	312	33	45.93	132	35	01.54	3.6175456

BLUE DICK, ESMERALDA COUNTY, NEV.

On a high, bald ridge in the Palmetto Range, about 8 miles northwest of Lida and about the same distance north-northeast of Pigeon Spring. Road from Lida to Silver Peak passes about 4 miles east of station. A trail leaves road about 1 mile below summit on road and can be followed to station by going west, then north up ridge. There is no feed nor water near point.

Station mark: A triangulation tablet set in rock under center of cairn 9 feet high.

[Latitude 37° 30′ 23.33″. Longitude 117° 35′ 25.43″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
White Top	21	03	10.06	200	59	12.38	4.4287747
Waucoba	34	38	53.52	214	23	45.02	4.8145008
Black Mountain	64	53	38.05	244	30	31.69	4.7932844
Piper	70	13	03.73	250	00	44.76	4.5013097
White Mountain South	103	48	04.67	283	23	45.73	4.7811245
Lone Mountain	188	23	34.07	8	27	07.15	4.7644849
Montezuma	223	58	17.82	44	06	40.71	4.4636354
Stonewall	270	37	41.07	90	57	48.39	4.6876502
Gold Mountain	318	01	03.70	138	11	27.59	4.5782060
Magruder	340	02	35.49	160	04	10.89	4.0531807

GOLD MOUNTAIN, ESMERALDA COUNTY, NEV.

On the highest summit of Gold Mountain, a sharp, rocky peak 1.5 miles southeast of Oriental post-office (abandoned), now known as Old Town or Old Camp, and about 20 miles southeast of Lida post-office. Best reached from Old Camp, where there is good water and feed and which is reached from Lida post-office by a good wagon road. (Wheeler point, 1871–72?)

Station mark: A bronze triangulation tablet in solid rock, stamped "8144 V A," under a rock monument 6 feet high.

[Latitude 37° 15′ 09.13″ (37° 15′ 09.50″[a]). Longitude 117° 18′ 17.76″ (117° 18′ 18.09″[a]).]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Tin[a]	18	18	33.00	198	12	03.00	4.6305400
Montezuma[a]	174	12	45.00	354	10	41.00	4.6931600
Stonewall[a]	220	27	07.00	40	36	47.00	4.5584400
Tolicha[a]	267	34	42.00	87	52	41.00	4.6428500
Grape[a]	336	28	08.00	156	33	46.00	4.5406000
Waucoba	67	55	52.73	247	30	26.42	4.8288720
Black Mountain	91	25	31.52	270	52	06.99	4.9117079
White Top	95	14	03.60	274	59	44.33	4.5453611
White Mountain South	117	02	32.64	296	27	53.08	4.9738652
Magruder	129	23	32.11	309	14	44.03	4.4426453
Blue Dick	138	11	27.59	318	01	03.70	4.5783000
Montezuma	174	12	05.58	354	10	01.79	4.6932257
Stonewall	220	26	10.48	40	35	50.46	4.5585011

[a] B. D. Stewart, 1905.

LONE MOUNTAIN, ESMERALDA COUNTY, NEV.

For description of this station, see page 145.

[Latitude 38° 01′ 28.759″ (38° 01′ 28.83″ [a]). Longitude 117° 29′ 37.647″ (117° 29′ 37.51″ [a]).]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Montezuma[a]	342	19	03.38	162	23	55.68	4.5845027
Blue Dick[a]	8	27	07.15	188	23	34.07	4.7644840
Mount Grant	118	30	45.13	297	42	31.46	5.1093270
Toiyabe Dome	187	47	26.93	7	52	43.32	4.9570036
Cactus Peak	296	08	52.00	116	31	36.00	4.7817000
Diamond	316	23	25.00	136	36	13.00	4.6476800
Stonewall	325	21	47.00	145	38	27.00	4.8486600
Montezuma	342	18	57.00	162	23	49.00	4.5845027

[a] Urquhart, 1905.

MAGRUDER, ESMERALDA COUNTY, NEV.

(Not occupied.)

On the highest point of Magruder Mountain, a well-known mountain 3 or 4 miles southwest of Lida.

Station mark: A triangulation tablet in center of cairn 6 feet high.

[Latitude 37° 24′ 38.69″. Longitude 117° 32′ 48.56″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
White Top	43	07	46.12	223	02	13.54	4.2956894
Waucoba	43	35	46.78	223	19	03.89	4.7738605
Piper	89	50	15.96	269	36	21.55	4.5276844
Blue Dick	160	04	10.80	340	02	35.40	4.0531807
Montezuma	207	23	43.88	27	30	30.62	4.5506136
Gold Mountain	309	14	44.03	129	23	32.11	4.4426453

MONTEZUMA, ESMERALDA COUNTY, NEV.

For description of this station, see page 146.

[Latitude 37° 41′ 41.44″ (37° 41′ 41.3″ [a]). Longitude 117° 21′ 41.24″ (117° 21′ 41.24″ [a]).]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Magruder	27	30	30.62	207	23	43.88	4.5506138
Waucoba	37	39	33.03	217	16	02.41	4.9733803
Blue Dick	44	06	40.71	223	58	17.82	4.4636354
White Mountain South	85	24	53.55	264	52	07.86	4.8983360
Lone Mountain	162	23	55.68	342	19	03.38	4.5845027
Stonewall	307	06	21.81	127	18	08.86	4.5525871
Gold Mountain	354	10	01.79	174	12	05.58	4.6932257
Lone Mountain [a]	162	23	49.00	342	18	57.00	4.5845027
Cactus Peak [a]	256	56	58.00	77	14	55.00	4.6412400
Stonewall [a]	307	06	58.00	127	18	45.00	4.5526000
Gold Mountain [a]	354	10	41.00	174	12	45.00	4.6931600

[a] R. H. Chapman, 1905.

STONEWALL, NYE COUNTY, NEV.

For description of this station, see page 153.

[Latitude 37° 30′ 01.38″ (37° 30′ 01.30″ [a]). Longitude 117° 02′ 22.35″ (117° 02′ 22.43″ [a]).]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Gold Mountain	40	35	50.46	220	26	10.48	4.5585011
Blue Dick	90	57	48.39	270	37	41.07	4.6876502
Montezuma	127	18	08.86	307	06	21.81	4.5525871
Gold Mountain [a]	40	36	47.00	220	27	07.00	4.5584400
Montezuma [a]	127	18	45.00	307	06	58.00	4.5526000
Lone Mountain [a]	145	38	27.00	325	21	47.00	4.8480600
Diamond [a]	160	06	29.00	340	02	35.00	4.4410100
Cactus Peak [a]	204	29	12.00	24	35	09.00	4.5375000
Quartzite	268	24	01.00	88	50	11.00	4.8017100
Tolicha [a]	321	39	17.00	141	47	39.00	4.5159900

[a] R. H. Chapman, 1905.

CALIFORNIA.

PRIMARY TRAVERSE.

COLUSA, SACRAMENTO, AND YOLO COUNTIES.

SPECIAL SHEETS NOS. 19, 20, 21, AND 22.

Two lines of primary traverse were run by C. H. Birdseye, topographic aid, in 1905, as follows:

From Yolo northwest base (Coast and Geodetic Survey) east and north via county roads and Southern Pacific Railroad to Knights Landing, thence north and west along west bank of Sacramento River to Smokestack triangulation station.

From Knights Landing south and east along west bank of Sacramento River to Sacramento, tying to dome of State capitol.

Positions are given on the United States standard datum.

Geographic positions along highways from Yolo northwest base to Woodland.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Yolo northwest base (Coast Survey), in extreme southeast corner of SE. ¼ sec. 28, T. 10 N., R. 1 E., Mount Diablo meridian, 4¼ miles west of railroad passing thru Woodland and on north side of county road going west toward Madison and Capay Valley. Station mark: A needle hole in a German-silver plug inserted in a copper bolt in top of a granite block 35 inches long by 20 inches square at base and drest to 12 inches at top, with the letters "U. S. C. & G. S." cut on it, all 4.5 feet below surface, above which is a granite block 25 inches square by 26 inches deep, with the letters "U. S. C. & G. S. N. W. Yolo base" cut on it; in top of this block is a needle hole in lead in a copper bolt; top of block even with surface; a brick pier is built around this block to a height of 33¼ feet above ground	38	40	44.81	121	51	28.55
Woodland, 2.5 miles west of, center of crossroads	38	40	41.40	121	49	13.30
Woodland, 1.5 miles west of Browns Corners, center of crossroads	38	40	40.80	121	48	06.70
Woodland, 0.5 mile west of, intersection of Cemetery avenue and Main street	38	40	40.40	121	46	59.90
Woodland, 0.5 mile west of and 1 mile north of, center of crossroads	38	41	32.60	121	46	59.50
Woodland, 1 mile north of Southern Pacific station, 50 feet southwest of intersection of crossroads, 2 by 4 inch stake	38	41	32.10	121	45	52.60
Woodland, railroad crossing, 1.5 miles north of Southern Pacific station, on west side of road, junction of west rails	38	42	06.10	121	45	52.40

Geographic positions along Southern Pacific Railroad.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Woodland, 2 miles north of, road crossing, junction of west rails	38	42	35.3	121	45	40.9
Peart flag station, middle of road crossing, east rail	38	43	02.5	121	45	29.9
Cache Creek railroad bridge, 200 feet north of west rail at middle of crossroad	38	43	26.9	121	45	17.9
Lochanour flag station, point is center of track and road crossing 1,500 feet north of warehouse	38	44	33.0	121	44	44.8
Curtis flag station (500 feet north of milepost 91), at road crossing on township line, center of track	38	44	57.7	121	44	32.4
Milepost 92, 20 feet south of, center of track opposite iron post, elevation 30 feet	38	45	38.6	121	44	11.9
Knights Landing, 1.5 miles south of, private road crossing, center of track at south end of north guard rails	38	46	42.0	121	43	40.2
Milepost 94, center of track opposite	38	47	16.0	121	43	22.7
Knights Landing, road crossing 0.5 mile south of Southern Pacific station, center of road and track	38	47	46.3	121	43	07.4
Knights Landing (Grafton post-office), in west wall, south abutment of railroad bridge over Sacramento River, tablet	38	48	09.4	121	42	56.0

Geographic positions along west bank of Sacramento River from Knights Landing to Howells Point.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Knights Landing, 1 mile northwest of, opposite temporary bench mark marked "35," center of levee road	38	48	42.3	121	43	25.4
Knights Landing, 1.12 miles northwest of, west edge of road at white gate	38	49	04.3	121	43	27.9
Knights Landing, 1.8 miles northwest of, opposite temporary bench mark marked "35," middle of levee road	38	49	25.1	121	43	25.2
Knights Landing, 2.8 miles northwest of, opposite temporary bench mark 35, north end of large warehouse, center of levee road	38	50	19.6	121	43	49.2
Darby Camp (Fair ranch), 3.4 miles east of, opposite temporary bench mark marked "16," elevation 36 feet, center of levee road	38	51	09.0	121	43	27.2
Darby Camp, 2.3 miles east of, opposite temporary bench mark marked "15," elevation 36 feet, center of levee road	38	51	40.5	121	44	16.7
Darby Camp, 1.3 miles east of, opposite old house, on north side of levee, standard bench-mark post stamped "39 B 1904"	38	52	15.4	121	44	58.1
Fair ranch house at Darby Camp, at east gate to farmyard, temporary bench mark, elevation 34 feet	38	51	46.6	121	45	47.2
Fair ranch, 1.5 miles west of, temporary bench mark No. 11, elevation 37 feet, on gatepost on levee, south of Rough and Ready landing, center of levee opposite bench mark	38	51	07.5	121	47	11.1
Smokestack triangulation station (smokestack of Reclamation pumping plant district No. 8)	38	55	33.2	121	52	51.5

Geographic positions along west bank of Sacramento River from Knights Landing to Sacramento.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Knights Landing, 0.5 mile south of Southern Pacific station, road crossing, center of road and track	38	47	46.3	121	43	07.4
Knights Landing, 1.5 miles southeast of, road turns south, 25 feet southwest of temporary bench mark, elevation 29 feet	38	47	45.7	121	41	58.7
Knights Landing, 2.6 miles southeast of, opposite north gatepost to Mr. Lippincott's house, center of road	38	46	39.4	121	41	23.2
Knights Landing, 3 miles southeast of, 75 feet south of timber, in west edge of levee	38	46	10.4	121	41	33.4
Knights Landing, 3 miles southeast of, on line with fence opposite standard iron post, center of levee	38	45	49.5	121	41	13.3
Grays Bend, 0.5 mile north of, 400 feet north of township road, in west edge of levee	38	44	59.7	121	40	38.0
Grays Bend, opposite creamery door, center of levee	38	44	34.9	121	40	23.9
Grays Bend, 0.25 mile northeast of, road turns east, leaving river, 35 feet northwest of temporary bench mark marked "29 D"	38	44	47.0	121	40	03.9
Grays Bend, 0.75 mile northeast of, 30 feet north of gate and 1,000 feet southwest of P. Goettsch's dairy ranch, on top of levee, standard bench-mark post	38	44	55.5	121	39	38.7
Grays Bend, 0.75 mile east of, temporary bench mark marked "24 D" on power-line pole	38	44	57.4	121	39	12.0
Grays Bend, 3 miles east of, center of old windmill on edge of tule, temporary bench mark marked "20 D"	38	45	30.2	121	37	20.1
Grays Bend, 3.75 miles east of, 300 feet north of fence line and on edge of timber, 1 mile west of Sacramento River, old cottonwood tree	38	45	25.8	121	36	35.8
Doyle's ranch, 0.75 mile west of, 20 feet south of road on top of back levee	38	45	31.4	121	36	21.2
Doyle's ranch, 0.5 mile south of, junction of river and back levees, center of levee at road at wire gate	38	44	59.1	121	35	46.9
Doyle's ranch, 1.25 miles south of, at large gate by large oak tree, west edge of levee	38	44	26.2	121	36	07.7
Doyle's ranch, 2 miles south of, temporary bench mark, elevation 33 feet, west edge of levee, opposite bench mark	38	43	51.1	121	36	18.1
Hushey's bee ranch, 200 feet east of old yellow house, west edge of levee, temporary bench mark marked "32 D"	38	43	20.3	121	36	21.1
Elkhorn weir, station is standard tablet set in north wall of wier, marked "30 B"	38	42	34.5	121	36	58.9
Elkhorn, 2 miles north of, 100 feet east of old barn, in root of large oak tree, temporary bench mark marked "25 D"	38	41	55.5	121	37	51.6
Elkhorn saloon, 55 feet southeast of southeast corner of, stake in top of levee	38	40	37.3	121	37	49.3
Elkhorn, 1 mile south of, 1,200 feet north of Mr. Perkins's house (open across river), opposite white flag marked "Sta. 224 A," center of levee	38	39	58.9	121	37	03.6
Elkhorn, 2 miles south of, opposite south window of M. F. Silva's house (open across river), center of levee	38	39	19.9	121	36	21.2
Elkhorn, 3 miles south of, in front of Mr. Matalock's house, center of levee over water pipe	38	38	34.4	121	35	33.1
Elkhorn, 3.5 miles southeast of, junction of river and back levees on west edge of Fair ranch, on south side of road and west side of old canal, nail with flag	38	38	37.2	121	34	59.2
Fair ranch, 1 mile southeast of, east edge of road, southeast of fence corner, flag marked "Sta. 242"	38	38	02.5	121	33	49.4
Fair ranch, 2 miles southeast of, in front of Mr. Cassleman's house, opposite temporary bench mark, elevation 29 feet, center of road	38	37	25.7	121	33	45.3
Lehman's hop yard, by water tank on east side of levee road, iron post stamped "32 B"	38	36	35.5	121	33	35.1
Washington, 2 miles northwest of, on east side of fence where road leaves river, temporary bench mark, a nail in base of telephone pole, elevation 31 feet (capitol dome visible from point)	38	35	49.1	121	32	46.7
Washington, 2 miles west of west end of switch, nail in west tie leading to switch block, center of track (capitol dome visible from point)	38	35	14.5	121	32	41.7
Washington (Broderick post-office), street crossing on west edge of, 15 feet north of old railroad track in center of north-south street (Fifth street)	38	35	16.6	121	30	44.3
Sacramento, bridge over Sacramento River, center of railroad track under cross arm in center of drawbridge	38	35	09.1	121	30	19.8
Sacramento, capitol dome, U. S. standard	38	34	37.4	121	29	34.3

MONTANA.

TRIANGULATION STATIONS.

FERGUS COUNTY.

MOCCASIN MOUNTAIN, MAIDEN, AND KENDALL QUADRANGLES.

During the season of 1905 H. L. Baldwin, jr., controlled an area of 800 square miles, based on the positions of Judith and Big Snowy, as published on page 305, Bulletin No. 122. Azimuth observations were made at stations Skaggs and Fence Corner, the weighted mean of which was adopted in computing the positions of 10 occupied and 12 unoccupied stations. Positions are given on the Bozeman astronomic datum of the Wheeler Survey of 1873.

BIG SNOWY, FERGUS COUNTY.

On highest summit of Big Snowy Mountains, south and east of Half Moon Pass, elevation 8,600 feet. A monument was found with 5-foot base and 7 feet high. It was enlarged to oval shape, 9 feet in large rdiameter and 5 feet in smaller diameter, so as to be seen from points to northward.

Station mark: Rock monument.

Reference mark: A bronze tablet cemented in decomposed limestone rock, true azimuth 155° 35′, distant 12.1 feet.

[Latitude 46° 45′ 12.30″. Longitude 109° 18′ 48.80″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Crazy	42	37	36.00	221	55	45.00	5.0419500
Neihart	104	13	56.00	283	17	23.00	5.0661220
Judith	187	42	20.00	7	46	24.00	4.7178170
South Moccasin	[a] 160	27	40.19	340	17	56.98	4.7008583
Judith	[a] 187	38	46.00	7	42	47.44	4.7178170
Fox Pass	[a] 198	38	56.87	18	49	47.22	4.7669659

[a] Observed azimuth, 1905.

DOGMELLE, FERGUS COUNTY.

About 2 miles east of the Claggett road, on a prairie mesa lying between Dog and Armelle creeks, 2 miles southeast of a large ranch house supposed to belong to Fergus.

Station mark: An iron bench-mark post set 3 feet in the ground.

Reference mark: An "Ayer's Sarsaparilla" bottle buried 6 inches below surface of ground on line to North Moccasin and covered with a small pile of rocks, true azimuth from station 75° 07′, distant, 5.1 feet.

[Latitude 47° 20′ 47.58″. Longitude 109° 17′ 53.03″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Pyramid	0	03	42.13	180	03	41.10	4.3492569
South Moccasin	43	59	49.54	223	49	22.57	4.4127832
North Moccasin	75	06	39.67	254	59	12.46	4.1209595
Fergus	273	03	50.89	93	10	26.41	4.0533075
Fox Pass	301	01	10.49	121	11	22.97	4.3106950
Judith	337	51	12.56	157	54	34.18	4.1851827

FENCE CORNER, FERGUS COUNTY.

On the high table-land one-half mile west of Cottonwood Creek; 36 feet north and 44 feet west of the junction of a road from the north with the east-west road; junction is probably the southwest corner of sec. 6, T. 15 N., R. 17 E.

Station mark: An iron bench-mark post set 3 feet in the ground.

[Latitude 47° 05′ 09.38″. Longitude 109° 36′ 57.95″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
South Moccasin	210	41	57.79	30	45	31.47	4.0800695
Pyramid	254	31	19.88	74	45	17.96	4.3980464
Tufted Pine	280	47	33.72	101	03	20.45	4.4439395

FERGUS, FERGUS COUNTY.

On a high bluff 1.5 miles northeast of Andrew Fergus's ranch.

Station mark: An iron bench-mark post set 3 feet in ground.

Reference mark: Beer bottle buried with top 8 inches below surface, true azimuth from station 83° 30′, distant 6.4 feet.

[Latitude 47° 20′ 27.66″. Longitude 109° 08′ 55.23″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Judith	22	12	36.41	202	09	22.92	4.1661345
North Moccasin	83	29	38.15	263	15	35.56	4.3841602
Dogmelle	93	10	26.41	273	03	50.89	4.0533075
Fox Pass	327	59	35.28	148	03	12.53	4.0692367

FOX PASS, FERGUS COUNTY.

About 2 miles northeast of summit of Fox Pass on highest mountain and 1 mile southeast of Cone Butte.

Station mark: The signal consisting of several small trees supported by wires on highest part of hill.

Reference mark: A bronze triangulation tablet cemented in a lime rock set in the ground, true azimuth from station 80° 15′, distant 4.5 feet.

[Latitude 47° 15′ 05.48″. Longitude 109° 03′ 59.59″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Big Snowy	18	49	47.22	198	38	56.87	4.7666659
Tufted Pine	31	26	36.92	211	18	14.62	4.4129533
Pyramid	56	13	50.18	236	03	37.84	4.3253830
Judith	72	55	15.24	252	48	24.85	4.0900705
North Moccasin	103	26	20.83	283	08	41.638	4.4931041
Dogmelle	121	11	22.97	301	01	10.49	4.3107950
Fergus	148	03	12.53	327	59	35.276	4.0692667
Skaggs	357	01	47.15	177	02	19.88	4.2592824

JUDITH, FERGUS COUNTY.

On highest peak of Judith Mountains, about 3 miles north of Maiden, Mont.

Station mark: A monument of rocks 6 feet in diameter at base and 8 feet high, with tree in center erected on site of original station, the monument of sticks and rocks having disappeared.

Reference marks: A tablet cemented in a small sloping rock, true azimuth from station 147° 10′, distant 7.5 feet; 4-inch pine tree blazed on side toward station, marked with triangle, true azimuth from station 181° 20′, distant 34 feet; 5-inch pine tree, blazed on side toward station, marked with triangle, true azimuth from station 288° 14′, distant 44.5 feet.

[Latitude 47° 13′ 08.09″. Longitude 109° 13′ 18.60″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Big Snowy	7	42	47.44	187	38	46.00	4.7178179
Pyramid	35	26	40.81	215	23	27.66	4.0005764
South Moccasin	79	30	17.78	259	16	30.29	4.3829514
North Moccasin	120	15	26.24	300	04	38.02	4.3315302
Dogmelle	157	54	34.18	337	51	12.56	4.1851827
Fergus	202	09	22.92	22	12	36.41	4.1661345
Fox Pass	252	48	24.85	72	55	15.25	4.0900705
Skaggs	318	43	15.13	138	50	37.71	4.2855418

NORTH MOCCASIN, FERGUS COUNTY.

On the north peak of the North Moccasin group of mountains.

Station mark: A bronze tablet loosely cemented in the very loose limestone rock on summit.

Signal: A fir tree erected over tablet and supported by three guy-wires.

Reference marks: Small pine tree, true azimuth from station 189° 36′, distance to base of tree 9.4 feet; small pine tree, true azimuth from station 124° 41′, distance to base of tree 18.3 feet.

[Latitude 47° 18′ 57.20″. Longitude 109° 28′ 00.96″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
South Moccasin	18	44	55.29	198	41	55.07	4.2062696
Dogmelle	254	59	12.46	75	06	39.67	4.1209595
Fergus	263	15	35.56	83	29	38.15	4.3841602
Fox Pass	283	08	41.64	103	26	20.83	4.4931041
Judith	300	04	38.02	120	15	26.24	4.3315202
Pyramid	325	57	37.96	146	05	03.40	4.3586092

PYRAMID, FERGUS COUNTY.

Station is on bare peak of that name 4 miles southwest of Maiden and is easily ascended from any direction.

Station mark: A 2-inch gas pipe 1 foot long projecting 1 inch above top of ground and cemented into the compact but fissured rock on summit and about 4 feet north thereof.

[Latitude 47° 08′ 43.89″. Longitude 109° 17′ 54.17″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Fence Corner	74	45	17.96	254	31	19.88	4.3980464
South Moccasin	101	46	11.52	281	35	46.59	4.2631779
North Moccasin	146	05	03.40	325	57	37.96	4.3586092
Dogmelle	180	03	41.10	0	03	42.13	4.3492569
Judith	215	23	27.66	35	26	49.81	4.0005064
Fox Pass	236	03	37.84	56	13	50.18	4.3253830
Tufted Pine	345	08	37.70	165	10	27.13	4.0899092

SKAGGS, FERGUS COUNTY.

On edge of bluff 1.5 miles south of Skagg's ranch and about 8 miles east of Gilt Edge post-office. Is probably in sec. 3, T. 15 N., R. 21 E., near southwest corner.

Station mark: An iron bench-mark post set 3 feet in ground.

Reference marks: An upright beer bottle, cork 8 inches below surface of ground; distant 6.20 feet, true azimuth from station 2° 23′.

[Latitude 47° 05′ 18″. Longitude 109° 03′ 14.96″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Tufted Pine	70	18	43.30	250	09	49.00	4.2139046
Judith	138	50	37.71	313	43	15.13	4.2855408
Fox Pass	177	02	19.88	357	01	47.15	4.2592824

SOUTH MOCCASIN, FERGUS COUNTY.

On the middle peak of the south group of Moccasin Mountains, between Warm Spring and Big Spring creeks.

Station mark: A bronze tablet cemented in a large rock set on top of hill, over which is placed a pine tree 12 feet high, 10 feet spread of limbs, held in position by wires.

Reference trees: Pine 4 inches in diameter true azimuth from station 195°, 21.3 feet distant. Pine 4 inches diameter, 266° 30′ from station, 32.6 feet distant.

[Latitude 47° 10′ 44.08″. Longitude 109° 32′ 06.41″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Fence Corner	30	45	31.47	210	41	57.79	4.080065
North Moccasin	198	41	55.07	18	44	55.29	4.20[illegible]
Dogmelle	223	49	22.57	43	59	49.54	4.412732
Judith	259	16	30.29	79	30	17.78	4.382951
Pyramid	281	35	46.59	101	46	11.52	4.263179
Tufted Pine	306	21	22.68	126	33	36.52	4.41925[illegible]
Big Snowy	340	17	56.98	160	27	40.19	4.700583

TUFTED PINE, FERGUS COUNTY.

On highest rounded hill about 9 miles east of Lewistown and 3 miles southwest of Flat Mountain. Reached from Lewistown via road up Boyds Creek for 5 miles, then take right-hand branch; 2 miles farther road branches again; take right-hand road to coal mine, thence to top of hill.

Station mark: The base of the trunk of a pine tree 14 inches in diameter with a tufted top 30 feet above-ground.

Reference mark: Bronze triangulation tablet set in limestone rock at highest point of hill, true azimuth from station 227° 23′, distant 14.6 feet.

[Latitude 47° 02′ 18.82″. Longitude 109° 15′ 24.78″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Fence Corner	101	03	20.45	280	47	33.72	4.4[illegible]
South Moccasin	126	33	36.52	306	21	22.67	4.41925[illegible]
Pyramid	165	10	27.13	345	08	37.70	4.0[illegible]
Fox Pass	211	18	14.62	31	26	36.92	4.4[illegible]
Skaggs	250	09	49.00	70	18	43.30	4.213[illegible]

The following positions are located by three or more intersections:

NORTH MOCCASIN MOUNTAINS, MIDDLE PEAK.

[Latitude 47° 17′ 44.64″. Longitude 109° 29′ 04.28″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Pyramid	319	45	24	139	53	36	4.3[illegible]
North Moccasin	210	41	14	30	42	01	3.415[illegible]

EASTERN OF TWO TREES.

[Latitude 47° 17′ 32.4″. Longitude 109° 36′ 15.5″.]

Middle North Moccasin	267	33	55	87	39	12	3.95[illegible]
South Moccasin	337	24	29	157	27	32	4.135[illegible]

NIPPLE-SHAPED HILL, HIGHEST TREE.

[Latitude 46° 57′ 30″. Longitude 108° 42′ 53″.]

To station—	Azimuth.	Back azimuth.	Log distance.
	° ′ ″	° ′ ″	*Meters.*
Pyramid			4. 69020
Judith			4. 68303

LEWISTOWN HIGH SCHOOL (CENTER OF BUILDING).

[Latitude 47° 03′ 45.55″. Longitude 109° 25′ 34.23″.]

Pyramid			4. 12641
South Moccasin			4. 18590

SOUTH MOCCASIN MOUNTAINS (NORTHWEST PEAK).

(Rock monument 5 feet high.)

[Latitude 47° 11′ 32.28″. Longitude 109° 32′ 16.40″.]

Judith			4.38252
South Moccasin			3. 17699

JUDITH MOUNTAINS (MIDDLE WEST PEAK).

[Latitude 47° 09′ 10.82″. Longitude 109° 21′ 14.62″.]

Judith			4. 09395
Dogmelle			4. 34106

PORPHYRY PEAK.

[Latitude 47° 12′ 54.95″. Longitude 109° 15′ 55.70″.]

Pyramid			3. 91086
South Moccasin			4. 31866

WINDMILL.

[Latitude 47° 04′ 21″. Longitude 109° 31′ 49.34″.]

South Moccasin			4. 07320
Fence Corner			3. 82476

BLACK BUTTE, NORTH POINT OF DOUBLE TOP.

[Latitude 47° 14′ 14.90″. Longitude 108° 58′ 14.27″.]

Judith			4. 28185
Dogmelle			4. 44056

CONE BUTTE.

[Latitude 47° 15′ 35.95″. Longitude 109° 04′ 17.09″.]

Judith			4. 08887
Fergus			4. 03092

LINDSY'S RANCH HOUSE.

[Latitude 47° 13′ 50.80″. Longitude 109° 26′ 24.75″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Pyramid			4.15698
Judith			4.21990

SMALL TREE ON SUMMIT OF HILL WEST OF BARNES KING MINE.

[Latitude 47° 17′ 28.82″. Longitude 109° 28′ 29.91″.]

Pyramid			4.32258
Dogmelle			4.16781

DEERLODGE, GRANITE, POWELL, AND RAVALLI COUNTIES.

PHILIPSBURG AND SAPPHIRE QUADRANGLES.

During the season of 1905 H. L. Baldwin, jr., topographer, extended triangulation eastward from stations Quigg and Willow to stations Haggin and Powell. Fourteen primary stations were occupied and numerous secondary points were located by intersections.

Positions are based on the adopted mean value of Hamilton and Helena astronomic stations and bases.

BENCH-MARK POST 5124, DEERLODGE COUNTY.

(Not occupied.)

[Latitude 47° 07′ 40.5″. Longitude 112° 53′ 43.6″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
West Mound			3.97380

HOWE, DEERLODGE COUNTY.

(Not occupied.)

On Continental Divide; elevation 10,475 feet.

[Latitude 46° 02′ 58.9″. Longitude 113° 12′ 53.7″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Haggin			4.01056
Red Lion			4.42528

SHORT PEAK, DEERLODGE COUNTY.

(Not occupied.)

East peak of ridge south of Haggin; elevation 10,240 feet.

[Latitude 46° 03′ 39.8″. Longitude 113° 06′ 19.3″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Haggin			3.50216
Warren			4.45502

WASHOE SMELTER SMOKE STACK, DEERLODGE COUNTY.

(Not occupied.)

Station mark: Center of stack; elevation of top 6,101 feet.

[Latitude 46° 06′ 44.1″. Longitude 112° 54′ 45″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Haggin			4.15681
Powell			4.43271

WARM SPRINGS, INSANE ASYLUM, DEERLODGE COUNTY,

(Not occupied.)

[Latitude 46° 10′ 474″. Longitude 112° 47′ 28.1″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Powell		322 50 00	4.37901
Haggin		246 33 15	4.40769

WEST MOUND, DEERLODGE COUNTY.

(Not occupied.)

The higher of two large bare mounds, 5 miles north of Anaconda; elevation 7,209 feet.

[Latitude 46° 12′ 19.66″. Longitude 112° 56′ 57.49″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Powell	172 08 38	352 07 22	4.21473
Haggin	40 58 53	220 52 35	4.23491

BARE HILL, GRANITE COUNTY.

(Not occupied.)

[Latitude 46° 02′ 59.4″. Longitude 113° 44′ 44.9″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Kent							3.6089
Emerine							4.2506

BLACK PINE, GRANITE COUNTY.

On a bare summit, on timbered ridge running north and south, 2 miles east of Willow Creek, 9 miles northeast of junction of Willow and Rock creeks, about 4 miles west of the deserted town of Combination. Best reached from Rock Creek by following up Willow Creek Valley and taking ridge leading to first timbered point south of station, thence north along ridge.

Station mark: A rock monument 6 feet in diameter at base and 8 feet high.

Reference marks: An aluminum tablet buried 4 inches below surface of ground (at point occupied by instrument) and covered with a small pile of loose rock; true azimuth from station 266° 56′, distant 4.7 feet; a 6-inch pine, blazed and marked with a triangle, true azimuth 198° 13′, distant 77.1 feet; a 6-inch pine, blazed and marked with a triangle, true azimuth from station 216° 26′, distant 62.9 feet.

[Latitude 46° 26′ 21.21″. Longitude 113° 26′ 46.46″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Warren	1	04	37.98	181	04	06.36	4.7002296
Emerine	27	25	19.45	207	17	13.86	4.4950967
Palisade	64	54	23.13	244	35	56.98	4.5576824
Quigg	103	25	49.94	283	14	01.08	4.3313046
Harvey	191	18	31.86	11	20	46.50	4.3038307
Chicago	233	20	21.44	53	34	12.42	4.4826353
Princeton	266	45	18.32	86	59	10.66	4.3900569
Red Lion	311	02	44.56	131	13	32.24	4.4048210

CHICAGO, GRANITE COUNTY.

On the highest prairie hill, 2 miles south of the town of New Chicago, but about 200 yards north of the highest point and very close to the east-west section line.

Station mark: Iron bench-mark post.

Signal: Black and white cloth, temporary in nature.

[Latitude 46° 36′ 07.14″. Longitude 113° 07′ 41.31″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Black Pine	53	34	12.42	233	20	21.44	4.4826353
Harvey	94	42	09.93	274	30	32.57	4.3115010
Princeton	359	45	32.84	179	45	35.23	4.2240469

CONGDON PEAK, GRANITE AND RAVALLI COUNTIES.

First rocky peak 2 miles south of Fox Peak. A wagon road leads from Rock Creek up Ross Fork Valley to mine about 8 miles distant. Best route is thence westward by trail 1 mile to Medicine Lake, thence southwest on trail 5 miles to Fox Peak, which is easily ascended from northeast end of spur; descend then to northwest about 400 feet in elevation to avoid slide rock on southwest face and thence along ridge southwest to peak.

Station mark: A rock monument 3 feet in diameter at base and 4 feet high.

[Latitude 46° 05′ 15.91″. Longitude 113° 46′ 09.63″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Warren	294 34 57	114 48 23	4.42313
Kent	36 45 38	216 44 36	3.48725

DOME-SHAPED MOUNTAIN, GRANITE COUNTY.

(Not occupied.)

Highest part.

[Latitude 46° 18′ 28″. Longitude 113° 46′ 46.4″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Quigg	....	13 39 41	4.30368
Black Pine	....	60 27 05	4.47006

EMERINE, GRANITE COUNTY.

On south knoll of the mountain of that name about 6 miles west of the junction of East Fork and Middle Fork of Rock Creek. Top of mountain is rocky and bare and difficult of ascent, the route from the south being perhaps the best.

Station mark: A rock cairn 8 feet in diameter at base and 9 feet high.

Reference mark: An aluminum tablet set in a sloping rock face, on the east side thereof, serves as a reference mark. True azimuth from station, 250° 20′, distant 4.22 feet.

[Latitude 46° 11′ 21.79″. Longitude 113° 37′ 57.96″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Kent	42 04 07 28	221 57 11.19	4.2675236
Palisade	124 03 35.67	303 53 16.85	4.3450147
Quigg	168 42 21 25	348 38 39.66	4.5233032
Black Pine	207 17 13 86	27 25 19.45	4.4950[illegible]67
Prairie	250 26 56.29	70 34 27.80	4.1529706
Haggin	284 52 32.27	105 15 48.33	4.6338509
Warren	328 50 55.22	148 58 27.43	4.4169071

FISH PEAK, GRANITE COUNTY.

(Not occupied.)

On Continental Divide; elevation 10,240 feet.

[Latitude 46° 00′ 25.5″. Longitude 113° 20′ 03.8″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Warren							3.[illegible]
Emerine							4.4872

FOURTH PROMINENT PEAK SOUTHWEST OF MOUNT WARREN, GRANITE COUNTY.

(Not occupied.)

Station mark: A rock monument.

[Latitude 45° 56′ 25.75″. Longitude 113° 30′ 53.86″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Warren							3.83749
Kent							4.40899

FOX PEAK, GRANITE AND RAVALLI COUNTIES.

A wagon road leads up Ross Fork Valley from Rock Creek to mine about 8 miles distant. Best route is thence westward by trail 1 mile to Medicine Lake, thence southwest on trail 5 miles to Fox Peak, which is easily ascended from northeast end of spur.

Station mark: Rock monument.

[Latitude 46° 06′ 12.53″. Longitude 113° 45′ 53.02″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Warren	298	17	00	118	30	13	4.43060
Kent	27	32	44	207	31	31	3.67633

HAGGIN, GRANITE COUNTY.

On Haggin Peak, 8 miles southwest of Anaconda; easiest ascent is from end of wood road leading south from the 9-mile house on Warm Spring Creek, thence up ridge between Barker and Haggin lakes. Horses can be ridden to an elevation of 9,800 feet; thence on foot to summit of mountain along ridge to east. Ascent can also be made from Anaconda by taking road leading to the waterworks reservoir or Hearst Lake, but animals can be taken only a few hundred feet higher; ascent on ridge west of lake must then be made on foot, a 2,000-foot climb. Elevation 10,598 feet.

Station mark: A rock cairn 6 feet in diameter at base and 7 feet high.

Reference marks: An aluminum tablet set in large granite rock, true azimuth from station 211° 13′, distant 9 feet 9 inches.

[Latitude 46° 05′ 19.38″. Longitude 113° 05′ 41.79″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Warren	68	28	07.86	248	12	26.01	4.4810782
Emerine	105	15	48.33	284	52	32.27	4.6338509
Prairie	119	40	02.64	299	24	17.23	4.5095144
Red Lion	160	25	20.01	340	20	53.16	4.3733384
Princeton	176	28	41.03	356	27	17.05	4.6061458
Powell	197	03	43.66	17	08	46.54	4.4852933

HARVEY, GRANITE COUNTY.

On the bare summit at west end of Harvey Ridge, near headwaters of Cow Creek; north side of hill is timbered but south and east slopes are mostly bare. Is about 12 miles west of New Chicago.

Station mark: An aluminum tablet set in red-sandstone rock.

Reference marks: An 8-inch white pine trimmed and blazed with a triangle cut in blazed part and a large spike in center thereof, true azimuth from station 310° 13′, distant 87 feet.

[Latitude 46° 37′ 00.42″. Longitude 113° 23′ 40.95″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Black Pine	11	20	46.50	191	18	31.86	4.3038307
Chicago	274	30	32.57	94	42	09.93	4.3115010
Princeton	311	46	47.15	131	58	26.04	4.4402764
Red Lion	337	22	15.76	157	30	49.91	4.5062158

MOORE, GRANITE COUNTY.

(Not occupied.)

On Continental Divide, near southwest end of Methodist Mountains.

[Latitude 45° 57′ 51.62″. Longitude 113° 23′ 36.62″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Emerine							4.49301
Kent							4.51760

NEW CHICAGO, GRANITE COUNTY.

(Not occupied.)

Station mark: Center of church spire.

[Latitude 46° 37′ 42.8″. Longitude 113° 08′ 17.3″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Black Pine	....	228 12 30	4.50033
Chicago	....	165 26 40	3.48436

PEAK 2 MILES EAST OF QUIGG, GRANITE COUNTY.

(Not occupied.)

[Latitude 46° 28′ 52.1″. Longitude 113° 40′ 45.25″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Palisade	....	....	4.39601
Emerine	....	....	4.51356

PEAK EAST OF HAGGIN AND 6 MILES SOUTHWEST OF ANACONDA, GRANITE COUNTY.

(Not occupied.)

Take road up Sheep Gulch from Anaconda and at summit thereof a wood road leads south across ravine to ridge, on which the peak is situated; follow ridge to summit.

Station mark: A rock monument 3 feet in diameter at base and 4 feet high.

[Latitude 46° 04′ 53.9″. Longitude 113° 03′ 55.4″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Powell	192 34 37	12 38 23	4.48779
Haggin	109 01 00	289 00 00	3.38332

POINT LOOKOUT, GRANITE COUNTY.

(Not occupied.)

Shaft house of Kent and Congdon mine.

[Latitude 46° 07′ 35.4″. Longitude 113° 39′ 45.9″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Fox	....	....	3.91843
Emerine	....	....	3.86709

PRAIRIE, GRANITE COUNTY.

About 3 miles northeast of the junction of East Fork of Rock Creek with Ross Fork and West Fork of Rock Creek, on a high, nearly bare prairie hill.

Station mark: A pine tree standing among others 120 feet northeast of highest part of hill, with the lower branches trimmed. It is blazed 10 feet above ground on the southwest side and has a triangle on blaze.

Reference mark: An aluminum tablet set in rock about 2 inches below surface and covered with small rock pile; true azimuth from station, 243° 11′, distant 70 feet.

[Latitude 46° 13′ 55.461″. Longitude 113° 27′ 32.504″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Kent	54	29	06.79	234	14	39.52	4.5018240
Emerine	70	34	27.80	250	26	56.29	4.1529706
Quigg	144	38	06.66	324	26	52.39	4.5358043
Red Lion	252	29	55.33	72	41	15.15	4.3246712
Haggin	299	24	17.23	119	40	02.64	4.5095145
Warren	359	53	52.98	179	53	54.60	4.4331270

PRINCETON, GRANITE COUNTY.

Situated on Mount Princeton, west of the head of Princeton Creek and 4 miles north of Princeton post-office. It is easily reached by taking old road northward from Princeton post-office for 1.5 miles along west side of creek, thence up the bare hill to station.

Station mark: A bronze triangulation tablet cemented in a projecting rock at summit of hill, surrounded by a rock monument 4 feet in diameter at base and 5 feet high.

Reference mark: Tall bare trunk of a dead pine 2 feet in diameter; true azimuth from station 170° 18′, distant 111 feet 2 inches.

[Latitude 46° 27′ 04.62″. Longitude 113° 07′ 38.01″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Red Lion	16	44	24.32	196	41	20.78	4.2752007
Black Pine	86	59	10.66	266	45	18.32	4.3900569
Harvey	131	58	26.04	311	46	47.15	4.4402764
Chicago	179	45	35.23	359	45	32.84	4.2240669
Powell	314	01	46.23	134	08	24.19	4.2022534
Haggin	356	27	17.05	176	28	41.03	4.6061458

PROMINENT BARE HILL, GRANITE COUNTY.

(Not occupied.)

[Latitude 46° 16′ 17.66″. Longitude 113° 33′ 57.2″.]

To station	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Emerine							4.02074
Quigg							4.42035

QUIGG, GRANITE COUNTY.

A high rocky peak about 20 miles south of Quigley and about 3 miles east of the westernmost point of Rock Creek, from which point it is easily accessible along the ridge leading eastward and 1 mile north of a log cabin built in 1905, this cabin being 0.5 mile north of trail leading up ridge westward to Burnt Fork and Steubenville. The peak is about 4,100 feet above river, sparsely timbered on sides, with summit bare. About 2 miles to the east is a conical peak, bare on top and of about equal height.

Station mark: An aluminum tablet set in solid rock over which was erected a cairn 6 feet in diameter at base and 8 feet high.

Reference marks: Copper nail in notch on west side of pine tree blazed on north, east, and west sides (S); true azimuth from station 352° 48′, distant 53.4 feet. Copper nail in top of pine stub blazed on four sides; true azimuth from station 128° 01′, distant 27.2 feet. The third reference point left by Chapman in 1898 has disappeared.

[Latitude 46° 29′ 01.36″. Longitude 113° 43′ 04.32″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Kent	7	08	23.70	187	05	07.94	4.6705561
Palisade	30	04	40.58	209	58	02.07	4.3711049
Willow	41	12	36.54	221	03	41.08	4.3803840
Black Pine	283	14	01.08	103	25	49.94	4.3313048
Red Lion	298	13	48.42	118	36	24.30	4.6580054
Prairie	324	26	52.39	144	38	06.66	4.5358044
Warren	339	56	16.26	160	07	30.80	4.7679905
Emerine	348	38	39 66	168	42	21.25	4.5233032
St. Mary	94	50	59.47	274	28	07.87	4.6069916
Miller	157	16	02.01	337	08	42.48	4.5212790
McLeod	167	13	20.58	347	04	26.19	4.8445761
Kamas	192	29	26.79	12	32	51.52	4.5532809

RED LION, GRANITE COUNTY.

On bare, rocky point 1.5 miles northwest of Red Lion mine and 2 miles east of the abandoned town of Ramsey. Elevation by Y level 8,773 feet. Reached by trail from Red Lion thru saddle 0.75 mile south of peak, also by same trail from Ramsey.

Station mark: A rock monument 5 feet in diameter and 6 feet high.

Reference marks: An aluminum tablet set in solid rock, true azimuth from station 20° 49′, distant 4.1 feet.

[Latitude 46° 17′ 20.08″. Longitude 113° 11′ 51.58″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Warren	31	10	23.72	210	59	06.91	4.5914006
Prairie	72	41	15.15	252	29	55.33	4.3246712
Quigg	118	36	24.30	298	13	48.42	4.6580054
Black Pine	131	13	32.24	311	02	44.56	4.4048210
Harvey	157	30	49.91	337	22	15.76	4.5962158
Princeton	196	41	20.78	16	44	24.32	4.2752007
Powell	247	30	16.10	67	39	46.92	4.2616440
Haggin	340	20	53.16	160	25	20.01	4.3733384

SUGAR LOAF, GRANITE COUNTY.

(Not occupied.)

[Latitude 46° 33′ 15.5″. Longitude 113° 16′ 42.2″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	Meters.
Princeton							4.21226
Black Pine							4.25907

SUMMIT OF HIGH, SPARSELY TIMBERED HILL, GRANITE COUNTY.

(Not occupied.)

[Latitude 46° 15′ 56.3″. Longitude 113° 52′ 33.2″.]

To station—	Azimuth.			Back azimuth,			Log. distance.
	°	′	″	°	′	″	Meters.
Willow							3.85481
Palisade							3.59243

THIRD PROMINENT PEAK SOUTHWEST OF MOUNT WARREN, GRANITE COUNTY.

(Not occupied.)

[Latitude 45° 57′ 00.2″. Longitude 113° 29′ 55.7″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	Meters.
Warren							3.72167
Kent							4.41771

WARREN, GRANITE COUNTY.

On Warren Peak, at southwest end of Methodist Mountains. Can be reached from Rock Creek and Moose Lake as follows: At 1 mile above Moose Lake leave wagon road and follow a trail leading east from old arrastre, going due east 3.5 miles. At a tree marked "C L" trail branches, the south fork going to Carp Lake, 1.5 miles distant, where camp may be established and mountain ascended by ridge west of lake—a dangerous climb, even without instrument.

Station mark: A rock cairn 8 feet in diameter at base and 8 feet high.

Reference mark: An aluminum tablet set in a rock, true azimuth from station 291° 36′, distant 9.85 feet.

[Latitude 45° 59′ 17.43″. Longitude 113° 27′ 30.26″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	Meters.
Kent	108	29	43.33	288	15	16.22	4.4362698
Emerine	148	58	27.42	328	50	55.22	4.4169071
Quigg	160	07	30.80	339	56	16.26	4.7679305
Prairie	179	53	54.60	359	53	52.98	4.4331270
Black Pine	181	04	06.36	1	04	37.98	4.7002295
Red Lion	210	59	06.91	31	10	23.72	4.5914006
Haggin	248	12	26.01	68	28	07.86	4.4810782

WILMA POST-OFFICE, GRANITE COUNTY.

(Not occupied.)

South end of Park's ranch house.

[Latitude 46° 11′ 31.01″. Longitude 113° 28′ 07.90″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Warren	....	....	4.35534
Emerine	....	....	4.10232

PIKES PEAK, POWELL COUNTY.

(Not occupied.)

Elevation, 9,359 feet.

[Latitude 46° 25′ 44.9″. Longitude 113° 00′ 38.5″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Black Pine	....	....	4.52456
Red Lion	....	....	4.32661

POWELL, POWELL COUNTY.

Best route to station is probably up Dempsey Creek, following the northwest prong thereof, and on to the flat south of station. It can also be reached from the north and east up Tincup Joe Creek, but is very difficult of access from the west.

Station mark: A rock cairn 8 feet high, with 6-foot base.

Reference marks: An aluminum tablet set in granite rock; true azimuth from station 201° 16′, distant 12.14 feet.

[Latitude 46° 21′ 05.67″. Longitude 112° 58′ 42.28″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Haggin	17 08 46.54	197 03 43.66	4.4652933
Red Lion	67 39 46.92	247 30 16.10	4.3516440
Princeton	134 08 24.19	314 01 46.23	4.2022534

DEER MOUNTAIN, RAVALLI COUNTY.

(Not occupied.)

[Latitude 46° 01′ 40.1″. Longitude 114° 03′ 13.3″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Warren	....	95 40 13	4.66574
Congdon	....	73 15 11	4.36157

KENT, RAVALLI COUNTY.

On a bare, rocky summit, the third from the north, near headwaters of west prong of Ross Fork of Rock Creek and 8 miles southwest of Kent and Congdon mine. A wagon road leads from Rock Creek up Ross Fork Valley to the mine. Best route is thence westward by trail 1 mile to Medicine Lake, thence southwest on trail 5 miles to Fox Peak, which is easily ascended from northeast end of spur; descend from peak to northwest about 400 feet in elevation to avoid slide rock on southwest face, and thence along ridge southwest to foot of station, passing east of the rocky peak lying between Congdon and and Kent peaks. Good camping place 1 mile northeast of station.

Station mark: A rock monument 7 feet in diameter at base and 7 feet high, on highest point of rocky summit.

Reference mark: An aluminum tablet 2 feet northwest of edge of monument, set in a large rock upon which the cairn rests; true azimuth from station 146° 24′, distant 3 feet 6 inches.

[Latitude 46° 03′ 56.23″. Longitude 113° 47′ 35.15″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Palisade	167	06	11. 90	347	02	50. 20	4. 4281934
Quigg	187	05	07. 94	7	08	23. 70	4. 6705581
Emerine	221	55	11. 19	42	04	07. 28	4. 2675236
Prairie	234	14	39. 52	54	29	06. 79	4. 5018240
Warren	288	15	16. 22	108	29	43. 33	4. 4362698

PALISADE, RAVALLI COUNTY.

On the double rocky top of a dividing ridge between Willow Creek and Burnt Fork, about 14 miles due east from Corvallis. Station is reached by going from Corvallis up Willow Creek to end of road, thence by trail to a point about 2 miles above old sawmill, where trail forks; take left-hand fork, which may lead to summit. Elevation about 8,500 feet.

Station mark: A rock cairn 5 feet in diameter at base and 7 feet high on highest part.

Reference mark: An aluminum tablet set in rock; true azimuth from station 116° 51′, distant 5 feet 10½ inches.

[Latitude 46° 18′ 02.34″. Longitude 113° 52′ 14.69″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Willow	119	16	39. 85	299	14	23. 17	3. 6661373
Quigg	209	58	02. 06	30	04	40. 58	4. 3711049
Black Pine	244	35	56. 98	64	54	23. 13	4. 5576824
Emerine	303	53	16. 85	124	03	35. 67	4. 3450147
Kent	347	02	50. 20	167	06	11. 90	4. 4281934

67, RAVALLI COUNTY.

(Not occupied.)

Lower of two timbered points.

[Latitude 46° 24′ 43.2″. Longitude 113° 49′ 28.3″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Palisade							4.10986
Willow							4.10200

68, RAVALLI COUNTY.

(Not occupied.)

Higher of two timbered points.

[Latitude 46° 25′ 59.8″. Longitude 113° 50′ 04.7″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Palisade							4.12014
Willow							4.10122

WILLOW, RAVALLI COUNTY.

A station in the base expansion, 15 miles northeast of Hamilton, on a bald summit of the range on the eastern side of the Bitterroot Valley and about 4,000 feet above it. Can be reached by following up Willow Creek from Corvallis to a half-finished log cabin, thence up a leading spur to station, the latter part of the way being through lodge-pole pines and difficult to travel. This station can be used in the extension of triangulation in any direction except eastward.

Station mark: A copper bolt in rock ledge. Signal is a pine tree placed over bolt and braced in position.

[Latitude 46° 19′ 15.72″. Longitude 113° 55′ 23.70″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Quigg	221	03	41.08	41	12	36.54	4.3803840
Palisade	209	14	23.17	119	16	39.85	3.6661373
Daly	37	52	02.00	217	47	48.75	4.0675630
El Capitan	46	38	13.00	226	17	46.10	4.7018800
South base	52	06	38.56	231	56	56.56	4.3401528
Ward (2)	59	11	33.24	238	55	53.90	4.5116330
Ward (1)	59	20	44.57	239	05	10.47	4.5084996
Astronomic pier	65	41	35.41	245	31	37.08	4.2891104
North base	74	49	03.84	254	38	55.30	4.2712506
St. Mary	131	06	13.50	310	52	19.34	4.5129510

NEW MEXICO.

TRIANGULATION STATIONS.

BERNALILLO, SOCORRO, AND VALENCIA COUNTIES.

During December, 1904, and January and February, 1905, triangulation was extended over three 30-minute quadrangles and one 15-minute quadrangle in the valley of the Rio Grande by R. H. Chapman, topographer.

A base 5.943 miles in length was measured near San Antonio on a tangent of the Santa Fe Railway and an azimuth observed at North base station, with a check azimuth at Socorro Peak. A position for North base station was assumed and computations made through closed figures to the vicinity of Albuquerque, where a tie was made to Black Rock, a point established by A. P. Davis in 1887, and to the cross on the Roman Catholic Church at Albuquerque, which is one of the points given by R. S. Woodward in his astronomic determination of 1885.

The difference in position at Black Rock was applied as a constant correction to the points in the scheme. The positions given are therefore based on those brought eastward from the base and astronomic determination at Fort Wingate, N. Mex., and are very close to the United States standard. Fifteen stations were occupied, while signals were erected on 15 stations, one of which, Magdalena Peak, was not occupied. There were 21 points intersected in the towns along the river or adjacent to the railroad lines.

ALBUQUERQUE, UNIVERSITY FLAGPOLE, BERNALILLO COUNTY.

At University of New Mexico, on east extension of Railroad avenue; on bench overlooking the city.

Station mark: Center of north flagstaff.

[Latitude 35° 04′ 53.82″. Longitude 106° 37′ 28.25″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Lunas	27	10	04.12	207	04	04.51	4.5435053
Isleta	27	47	37.00	207	43	55.00	4.3061900
Vulcan	116	32	50.76	296	27	47.22	4.1741868

VULCAN, BERNALILLO COUNTY.[a]

The northernmost of three rocky buttes on the Mesa Prieta, about 6 miles northwest of Albuquerque. Highest point in vicinity. Easily reached from south end of bridge at Albuquerque by wagon road to quarries 3 miles nearly south of triangulation station, thence by wagon northward on Mesa Prieta to east foot of butte (100 feet below top), thence by pack mule to summit.

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[a] Same as Black Rock station, A.P. Davis, 1887.

Station mark: An aluminum bench-mark tablet in flat basalt rock, weighing several tons, about 20 feet southwest of highest rock on butte.

Signal: A tripod about 16 feet high; above it a flagstaff.

Reference marks: Cross cut on solid rock 10.4 feet south; cross cut on solid rock 9 feet north.

[Latitude 35° 08′ 30.10″. Longitude 106° 46′ 16.00″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Lunas	3	51	15.25	183	50	17.86	4.5782076
Lucero	41	49	21.94	221	33	29.08	4.8028383
University of New Mexico	296	27	47.22	116	32	50.76	4.1741898
Albuquerque (Roman Catholic Church)	299	35	59.84	119	40	03.85	4.0919815
Isleta	350	50	36.00	170	52	18.00	4.1675806
Tome	351	47	34.38	171	49	53.30	4.6355958

CAMPANA, SOCORRO COUNTY.

A rocky, bare hill about 5 miles a little east of south of Carthage (Hilton Mines), about 10 miles southeast of San Antonio, on highest point of Sierra Campana. Wagon can be taken to point less than 0.25 mile northeast of station.

Station mark: A bronze triangulation tablet in solid rock, over which a tripod 7 feet high was erected.

Reference marks: A 60-penny spike in crevice of rock south; two 60-penny spikes driven in crevice of rock northwest.

[Latitude 33° 50′ 54.49″. Longitude 106° 42′ 44.06″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
South base	69	04	55.35	248	58	54.27	4.2520639
Chupadera	89	40	03.56	269	32	08.25	4.3412284
North base	101	27	03.61	281	21	43.40	4.1781198
Socorro	137	02	17.95	316	53	54.81	4.5300582
Canas	174	58	28.65	354	57	39.27	4.4127798

CANAS, SOCORRO COUNTY.

On north end of yellow ridge, about 10 miles due east of Rio Grande at Socorro, about 10 miles southeast of Publitos (Escondida crossing of river). It is about 1 mile from Chupadera (west) road, about 6 miles southeast of Ojo de la Parida, 5 miles southeast of Ojo Meado, and just south of road to cedar woods.

Station mark: A bronze triangulation tablet set in solid rock, over which is a tripod 12 feet high. Black and white band on signal.

[Latitude 34° 04′ 50.87″. Longitude 106° 44′ 12.44″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Chapadera	37	12	34.41	217	05	27.03	4.5121759
Socorro	87	19	20.50	267	11	45.36	3.3191492
Polvadera	115	16	57.63	295	08	14.89	4.4213690
Ladrones	140	51	00.84	320	39	15.56	4.7046962
Turututu	187	27	01.33	7	28	46.52	4.5660206
Campana	354	57	39.27	174	58	28.65	4.4127788

CHUPADERA, SOCORRO COUNTY.

A bare rocky mountain about 6 miles southwest of San Antonio and about 6 miles northwest of Elmendorf siding; easily ascended with horses.

Station mark: A bronze triangulation tablet in solid rock, over which is a tripod 6 feet high with black center pole.

[Latitude 33° 50′ 49.54″. Longitude 106° 56′ 57.42″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Socorro	177	12	41.76	357	12	15.32	4.3971451
Canas	217	05	27.03	37	12	34.41	4.5121759
North base	246	21	16.94	66	23	52.20	3.8931043
Campana	269	32	08.25	89	40	03.56	4.3412284
South base	319	51	01.33	139	52	55.20	3.9118757

ISLETA, SOCORRO COUNTY.

(Secondary.)

On highest point and at south end of black malpais hill, about 2 miles west of Isleta, locally known as Isleta Hill; easily ascended.

Station mark: Triangle cut in top of malpais bowlder.

Reference marks: Crosscut in solid rock 15 feet north; crosscut in solid rock 9 feet southeast.

[Latitude 34° 55′ 12.7″. Longitude 106° 43′ 40.0″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Lunas	26	15	22	206	12	55	4.16788
Vulcan	170	52	18	350	50	36	4.39604
University of New Mexico	207	43	55	27	47	37	4.30619
Tome	353	06	24	173	07	14	4.26313

NORTH BASE, SOCORRO COUNTY.

About 2 miles south of San Antonio station, on Atchison, Topeka and Santa Fe Railway. It is about 500 feet south of road crossing and 135 feet south of north end of and below first curve south of railway station. Signal and center 30 feet west of west rail.

Station mark: A bench-mark post set 3.5 feet in ground in one-half cubic yard of cement and sand.

Reference marks: Three standard iron posts set as follows: One 15 feet west of center, perpendicular to line measured; one 15 feet east of center, perpendicular to line measured; one 15 feet north of center on extension of line measured.

[Latitude 33° 52′ 31.23″. Longitude 106° 52′ 18.76″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
South base	11	29	16.93	191	28	35.70	3.9807180
Chupadera	66	23	52.20	246	21	16.94	3.8931043
Campana	281	21	43.40	101	27	03.61	4.1781158

POLVADERA, SOCORRO COUNTY.

A sharp rocky peak 4 miles southwest of Polvadera; locally called Polvadera Mountain and by some Limitar Mountain. Can be seen from valley (Rio Grande) from San Antonio nearly to Albuquerque, and is easily ascended from all sides.

Station mark: A bronze triangulation tablet in solid rock, over which is a cairn 8 feet high.

Reference marks: A cross cut on rock 16 feet south of center; a cross cut on rock 20.7 feet northwest of center.

[Latitude 34° 10′ 55.62″. Longitude 106° 59′ 44.10″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Magdalena	39	55	32.00	219	49	05.00	4.4410807
Sanders	111	25	16.31	291	15	04.31	4.4755401
Ladrones	163	40	41.19	343	37	40.18	4.4650208
Turututu	228	27	46.17	48	38	16.44	4.5816088
Canas	295	08	14.89	115	16	57.63	4.4213490
Socorro	345	57	31.31	165	58	38.26	4.1007498
Socorro (observed)				165	58	43.6	

SANDERS, SOCORRO COUNTY.

About 12 miles a little west of north of Magdalena, 4 miles west of west fence of Sander's pasture, on highest point of ridge north and south. Point has scattering cedar and piñon and shows sharp scarp toward east. Can be ascended by horse from any direction, but more easily from south or west.

Station mark: A bronze triangulation tablet in solid rock, over which is a cairn about 10 feet high.

Reference marks: Nail in blazed side of piñon stump 8.9 feet west of center. Blaze marked "B T △." Nail at bottom of blaze.

[Latitude 34° 16′ 48.61″. Longitude 107° 17′ 52.02″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Ladrones	228	47	47.00	48	54	59.73	4.4153166
Polvadera	291	15	04.31	111	25	16.31	4.4755601
Socorro	306	41	04.84	126	52	23.05	4.5866041
Magdalena	342	21	11.00	162	25	04.00	4.5269200

SOCORRO PEAK, SOCORRO COUNTY.

On the lower eastern peak of a double-topt mountain, about 3 miles west of Socorro. The point is bare except for scattering cedar scrub, and is easily reached from Socorro by wagon road to Coon's mines, thence by trail to ridge just south of summit.

Station mark: A bronze triangulation tablet in solid rock, over which is a tripod 12 feet high, with white flag over it and white bands below peak.

Reference marks: A cross cut in top of bowlder 18.3 feet west of center; a cross cut in top of bowlder 17 feet northeast of center.

[Latitude 34° 04′ 18.51″. Longitude 106° 57′ 44.77″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Sanders	126	52	23.05	306	41	04.84	4.5866041
Polvadera	165	58	38.26	345	57	31.31	4.1007899
Polvadera (observed)	165	58	43.60				
Canas	267	11	45.36	87	19	20.50	4.3191492
Campana	316	53	54.81	137	02	17.95	4.5300582
Chupadera	357	12	15.32	177	12	41.76	4.3971451

SOUTH BASE, SOCORRO COUNTY.

About 7.5 miles south of San Antonio and about 8.5 miles north of San Marcial, on Atchison, Topeka and Santa Fe Railway. It is 190 feet north of south end of tangent.

Signal: 30 feet west of west rail.

Station mark: Standard bench-mark post set 3.5 feet in ground, in one-half cubic yard of cement and cinders.

Reference marks: Standard bench-mark posts as follows: One 15.02 feet west of center, perpendicular to line of measurement; one perpendicular to line of measurement; one 15.12 feet south of center, in extension of measurement.

[Latitude 33° 47′ 26.97″. Longitude 106° 53′ 32.82″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Chupadera	139	52	55.205	319	51	01.326	3.9118757
North base	191	28	35.697	11	29	16.928	3.9807180
Campana	248	58	54.266	69	04	55.346	4.2520639

TURUTUTU, SOCORRO COUNTY.

On a black malpais hill, about 10 miles northeast of La Joya and one-half mile west from La Joya-Manzano road. Local name, Cerro Turututu.

Station mark: A bronze triangulation tablet set in solid rock, over which is a tripod 12 feet high. Tripod carries a 6-foot flagstaff.

Reference marks: Cross cut in rock 5.5 feet northeast; cross cut in rock 11.1 feet south.

[Latitude 34° 24′ 35.55″. Longitude 106° 41′ 05.53″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Canas	7	28	46.52	187	27	01.33	4.5660206
Polvadera	48	38	16.44	228	27	46.17	4.5810668
Ladrones	94	21	49.03	274	08	15.20	4.5666170
Lucero	123	59	58.97	303	41	18.76	4.7825605
Lunas	166	28	52.07	346	24	58.90	4.6498118
Tome	177	25	26.51	357	24	47.94	4.5849130

LUCERO, VALENCIA COUNTY.

A small rocky summit at east end of Lucero mesa, about 28 miles west of Los Lunas; easily ascended with saddle animals from north. Timber and a small amount of grass on mesa.

Station mark: A bronze triangulation tablet in solid rock, over which is a tripod about 12 feet high carrying a 4-foot bushy top.

Reference marks: Cross cut in rock 10.6 feet south of station; cross cut in rock 8.9 feet north of station; spike in blazed gum stump 21.4 feet southwest of station.

[Latitude 34° 42′ 51.08″. Longitude 107° 14′ 00.26″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Vulcan	221	33	29.08	41	49	21.91	4.8028363
Lunas	256	14	33.78	76	29	25.49	4.6120670
Tome	264	22	03.41	84	40	09.82	4.6878101
Turututu	303	41	18.66	123	59	58.92	4.7825605
Ladrones	336	13	46.07	156	18	49.68	4.5300700

LUNAS, VALENCIA COUNTY.

A high, rocky, sandy hill, 5 miles a little south of west of Los Lunas. Very prominent and locally known; horses can be ridden to top. Every station of scheme developed northward of San Antonio base is visible with exception of two base stations. Local name Sierra Los Lunas.

Station mark: A bronze triangulation tablet in solid rock, over which is erected a tripod 14 feet high, carrying a 6-foot flagstaff.

Reference marks: Cross cut in rock 8.9 feet north; cross cut in rock 6.75 feet west.

[Latitude 34° 48′ 04.20″. Longitude 106° 47′ 56.12″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Ladrones	32	53	11.65	212	43	27.00	4.6847658
Lucero	76	29	25.45	256	14	33.78	4.6120870
Vulcan	183	50	17.86	3	51	15.25	4.5782076
Albuquerque	202	44	57.25	22	49	57.57	4.5359000
Isleta	206	12	55.00	26	15	22.00	4.1678800
University of New Mexico	207	04	04.51	27	10	04.12	4.5435053
Tome	299	47	31.46	119	50	46.92	4.0018224
Turututu	346	24	58.90	166	28	52.07	4.6498118

TOME, VALENCIA COUNTY.

On a black malpais hill, about 5 miles south of Lunas and 3 miles northeast of Tome. Horses can be ridden to top.

Station mark: A bronze triangulation tablet cemented in solid rock, over which is a tripod 14 feet high, carrying a 6-foot flagstaff.

Reference marks: Cross cut in rock 15.3 feet north of station; cross cut in rock 7.25 feet south of station.

[Latitude 34° 45′ 22.15″. Longitude 106° 42′ 13.47″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Ladrones	44	31	16.94	224	18	18.09	4.6985359
Lucero	84	40	09.82	264	22	03.41	4.6878101
Lunas	119	50	46.92	299	47	31.46	4.0018224
Vulcan	171	49	53.30	351	47	34.38	4.6355953
Isleta	173	07	14.00	353	06	24.00	4.2631295
Turututu	357	24	47.94	177	25	26.51	4.5849130

SECONDARY TRIANGULATION STATIONS.

ALBUQUERQUE, BERNALILLO COUNTY.

	Latitude.			Longitude.			To station—	Log. distance.
	°	′	″	°	′	″		*Meters.*
Catholic Church cross	35	05	11.80	106	39	11.79	Lunas	4.5359000
Catholic Church (astronomic)	35	05	09.70	106	39	23.04	Vulcan	4.0919815
Old town court-house tower	35	05	40.15	106	40	06.40	Lunas	4.5397500
							Vulcan	4.0304000
Sawmill, dust burner	35	06	13.70	106	39	38.89	Lunas	4.5546900
							Vulcan	4.0373500

ISLETA, BERNALILLO COUNTY.

Church, east spire	34	54	32.97	106	41	33.74	Tome	4.23054
							Lunas	4.18818

BELEN, VALENCIA COUNTY.

Flour-mill tower	34	39	37.56	106	46	32.17	Tome	4.09668
							Lunas	4.19748

LA JOYA, VALENCIA COUNTY.

	Latitude.			Longitude.			To station—	Log. distance.
	°	′	″	°	′	″		*Meters.*
Railroad Station chimney	34	22	05.11	106	51	26.06	Polvadera	4.38462
							Ladrones	4.34601

LOS LUNAS, VALENCIA COUNTY.

	Latitude.			Longitude.			To station—	Log. distance.
Railroad windmill	34	48	16.25	106	44	08.43	Tome	3.79602
							Lunas	3.76340

RIO PUERCO BRIDGE, VALENCIA COUNTY.

	Latitude.			Longitude.			To station—	Log. distance.
Middle pier	34	23	39.44	106	50	44.43	Polvadera	4.43590
							Ladrones	4.35085

SAN ACACIA MESA, VALENCIA AND SOCORRO COUNTIES.

	Latitude.			Longitude.			To station—	Log. distance.
Top of mesa, corner at principal meridian and base line northwest.	34	15	36.28	106	53	12.92	Canas	4.38435
							Polvadera	4.12256

ALAMILLO, SOCORRO COUNTY.

	Latitude.			Longitude.			To station—	Log. distance.
Railroad windmill	34	14	28.05	106	54	21.70	Canas	4.37402
							Polvadera	4.02267

LEMITAR, SOCORRO COUNTY.

	Latitude.			Longitude.			To station—	Log. distance.
Church spire	34	09	38.29	106	54	25.48	Canas	4.25610
							Socorro	4.04525

LUIS LOPEZ, SOCORRO COUNTY.

	Latitude.			Longitude.			To station—	Log. distance.
Church spire	33	59	29.78	106	53	10.88	Campana	4.35434
							Canas	4.23018

MAGDALENA, SOCORRO COUNTY.

	Latitude.			Longitude.			To station—	Log. distance.
Schoolhouse	34	06	48.80	107	14	29.00	Ladrones	4.58447
							Sanders	4.28324
Railroad water tank	34	07	04.05	107	14	40.93	Polvadera	4.38124
							Sanders	4.27103

POLVADERA, SOCORRO COUNTY.

	Latitude.			Longitude.			To station—	Log. distance.
Church spire	34	12	26.60	106	55	15.32	Canas	4.34317
							Socorro	4.19094

SAN ANTONIO, SOCORRO COUNTY.

	Latitude.			Longitude.			To station—	Log. distance.
Windmill, railroad tank	33	54	26.34	106	52	00.97	Campana	4.19675
							Canas	4.35585
Old town church spire	33	55	00.53	106	51	51.77	Campana	4.20376
							Canas	4.33596

SOCORRO, SOCORRO COUNTY.

	Latitude.			Longitude.			To station—	Log. distance.
	°	′	″	°	′	″		*Meters.*
Court-house tower	34	03	20.86	106	53	33.80	Canas	4.16612
							Polvadera	4.22848
Old church, south spire	34	03	37.81	106	53	34.97	Canas	4.16433
							Chupadera	4.38444
School of Mines	34	03	59.25	106	54	12.96	Canas	4.18977
							Polvadera	4.18700

WATER CANYON (BRANCH RAILROAD), SOCORRO COUNTY.

Railroad tank	34	05	20.01	107	04	46.58	Polvadera	4.11136
							Sanders	4.46591

OKLAHOMA.

TRIANGULATION STATIONS.

LINCOLN, LOGAN, OKLAHOMA, AND PAYNE COUNTIES.

AGRA, CHANDLER, EDMOND, GUTHRIE, MALLON, MERRICK, QUAY, RIPLEY, AND SAC-FOX QUADRANGLES.

During the season of 1905 H. H. Hodgeson, topographer, extended triangulation from Wingard and Edmond, stations in the ninety-eighth meridian arc of the Coast and Geodetic Survey, eastward to the Indian Territory line.

Twenty-four stations were occupied and 18 points were located by intersections. Positions are given on the United States standard datum.

COX, NUMBER 9 COUNTY.

This station is 2,400 feet south and 500 feet east of the closing corner on the old Oklahoma–Indian Territory boundary line. Said closing corner is on line between secs. 1 and 12, T. 14 N., R. 6 E.

Station mark: A 20-inch post-oak tree having branches and top cut off. Theodolite elevated 30 feet.

[Latitude 35° 42′ 11.36″. Longitude 796° 37′ 06.51″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Harger	23	54	09.99	203	51	30.74	4.2301625
Buck	99	38	46.20	279	32	55.86	4.1846860
Mesecher	147	07	57.77	327	04	58.54	4.1519573

AGRA, LINCOLN COUNTY.

On the highest timbered hill in the SW. ¼ sec. 33, T. 17 N., R. 4 E., on land of F. B. Griswold, about 1 mile northwest of Agra.

Station mark: A 10-inch black-jack tree, top and branches cut off. Theodolite elevated 20 feet.

[Latitude 35° 54′ 14.65″. Longitude 96° 53′ 14.00″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Tryon	61	50	02.76	241	47	22.02	3.8922774
Paradise							4.5088629
Perkins	134	33	53.81	314	30	17.42	4.1126523
Mound	202	41	48.15	22	45	39.42	4.4064796
Cushing	232	54	08.27	52	57	44.69	4.0638806
Air	282	34	10.32	102	37	40.76	3.9648875
Buck	334	55	53.42	154	59	28.37	4.3382330

AGRA OIL TOWER, LINCOLN COUNTY.

(Not occupied.)

Station mark: Center of tower.

[Latitude 35° 53′ 47″. Longitude 96° 52′ 06.7″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Air							3.86900
Cushing							4.03863
Agra							3.27641

AIR, LINCOLN COUNTY.

On wagon-road right of way about 800 feet north of corner to secs. 4, 5, 8, and 9, T. 16 N., R. 5 E., on highest ground between secs. 4 and 5.

Station mark: An iron bench-mark post set 3 feet in ground and about 3 feet from east fence.

[Latitude 35° 53′ 09.37″. Longitude 96° 47′ 15.09″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Agra	102	37	40.76	282	34	10.32	3.9648875
Cushing	181	34	20.01	1	34	25.79	3.9541412
Indian	242	12	41.95	62	17	59.40	4.1855361
Buck	359	18	58.26	179	19	03.18	4.2487230
Mesecher	317	48	53.85	137	51	50.63	4.0525232

AVERY, LINCOLN COUNTY.

(Not occupied.)

German Church spire, 1 mile east of Avery.

[Latitude 35° 53′ 01.7″. Longitude 96° 44′ 02.2″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Indian							4.05806
Cushing							4.01324
Air							3.68505

BUCK, LINCOLN COUNTY.

About 1,200 feet east and 600 feet north of corner to secs. 4, 5, 32, and 33, Tps. 14 and 15 N., R. 5 E., on highest cultivated ground in quarter section belonging to H. M. Johnson.

Station mark: None.

Reference mark: A bronze triangulation tablet cemented in a stone set flush with ground at angle of fence. Theodolite elevated 10 feet. True azimuth to mark 240° 05′ 22″, distant 267 feet.

[Latitude 35° 43′ 34.12″. Longitude 96° 47′ 06.67″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Stuart	27	32	59. 36	207	29	08. 57	4. 3338131
Agra	154	59	28. 37	334	55	53. 42	4. 3382330
Air	179	19	03. 18	359	18	58. 26	4. 2487230
Mesecher	218	11	09. 19	38	14	00. 71	4. 0761618
Cox	279	32	55. 86	99	38	46. 20	4. 1846860
Harger	335	31	31. 07	155	34	41. 53	4. 2981235
Girdle							3. 8577614

CHANDLER STANDPIPE, LINCOLN COUNTY.

(Not occupied.)

Station mark: Center of standpipe.

[Latitude 35° 42′ 22″. Longitude 96° 52′ 47″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Buck							3. 94632
Girdle							3. 92795
Harger							4. 36352

GIRDLE, LINCOLN COUNTY.

About 1,000 feet southeast of corner to secs. 19, 20, 29, and 30, T. 14 N., R. 5 E., on land belonging to H. C. Glover.

Station mark: A 16-inch (girdled) post-oak tree having top and branches cut off. Theodolite elevated 20 feet.

[Latitude 35° 39′ 45.98″. Longitude 96° 48′ 09.62″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Stuart	34	45	08. 32	214	41	54. 36	4. 1678708
Harger	318	22	47. 73	138	26	34. 70	4. 1696384
Buck							3. 8577614

HARGER, LINCOLN COUNTY.

About 0.25 mile southeast of corner to secs. 29, 30, 31, and 32, and 600 feet south of line between secs. 29 and 32, T. 13 N., R. 6 E., on land of John Harger.

Station mark: A 20-inch post-oak tree having top and branches cut off. Theodolite elevated 27.5 feet.

[Latitude 35° 33′ 47.31″. Longitude 96° 41′ 39.85″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Stuart	86	46	38.39	266	39	38.00	4.2609290
Girdle	138	26	34.70	318	22	47.73	4.1696364
Buck	155	34	41.53	335	31	31.07	4.2981255
Cox	203	51	30.74	23	54	09.99	4.2301625

MESECHER, LINCOLN COUNTY.

About 1,500 feet west and 250 feet south of corner to secs. 5, 6, 31, and 32, T. 15 and 16 N., R. 6 E., on highest ground in quarter section owned by N. B. Mesecher.

Station mark: A 12-inch black-jack tree, the top and branches of which are cut off. Theodolite elevated 27 feet.

Reference mark: A 10-inch black-jack tree blazed and marked "B T △." True azimuth to mark 193° 23′ 52″, distance 226.2 feet.

[Latitude 35° 48′ 37.94″. Longitude 96° 42′ 13.23″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Air	137	51	50.63	317	48	53.85	4.0525232
Buck	38	14	00.71	218	11	09.19	4.0761048
Cox	327	04	58.54	147	07	57.77	4.1519573

PHEE, LINCOLN COUNTY.

On highest ground in the NW. ¼ sec. 23, T. 17 N., R. 2 E., on hay land owned by Daniel McPhee. North line of Lincoln County is about 800 feet north of station.

Station mark: A bronze triangulation tablet cemented in stone set flush with ground.

[Latitude 35° 56′ 22.73″. Longitude 97° 03′ 40.23″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Reece	74	27	42.29	254	23	54.12	4.0051680
Tryon							4.0670672
Perkins	231	25	57.32	51	28	28.59	3.9166136

SAC-FOX AGENCY WATER TANK, LINCOLN COUNTY.

(Not occupied.)

Station mark. Center of tank.

[Latitude 35° 40′ 21.4″. Longitude 96° 39′ 26.1″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Cox							3.68838
Buck							4.11448
Harger							4.10046

STUART, LINCOLN COUNTY.

In the SE. ¼ sec. 32, T. 13 N., R. 4 E., on land of C. A. Stuart, about 25 feet southeast of house, which is on highest land in said quarter. Observation for azimuth was made at this station November 7, 1905.

Station mark: A bronze triangulation tablet cemented in stone set flush with ground.

[Latitude 35° 33′ 13.45″. Longitude 96° 53′ 42.74″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Buck	207	29	08.57	27	32	59.36	4.3338131
Girdle	214	41	54.36	34	45	08.32	4.1678708
Harger	266	39	38.00	86	46	38.39	4.2609290

TRYON, LINCOLN COUNTY.

Station mark: The center of steeple on Christian Church in Tryon. Theodolite elevated 35 feet.

[Latitude 35° 52′ 15.05″. Longitude 96° 57′ 48.22″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Reece	104	53	00.28	284	45	45.93	4.2837655
Phee							4.0670672
Perkins	169	30	45.10	349	29	49.70	4.1137369
Agra	241	47	22.02	61	50	02.76	3.8922774

FLINN, LOGAN COUNTY.

In the NW. ¼ sec. 24, T. 15 N., R. 2 W. (Indian meridian), on property of T. O. Flinn, about 800 feet northeast of his house and on highest ground. This farm is known as the old Holbrook place.

Station mark: An iron bench-mark post, the cap of which extends 4 inches above ground.

Reference mark: A 10-inch blazed post-oak tree marked "B T △." True azimuth from station, 351° 36′ 13″, distant 100 feet.

[Latitude 35° 46′ 00.01″. Longitude 97° 22′ 02.35″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Edmond	36 41 12.41	216 37 45.79	4.1732601
Wingard	151 12 06.18	331 07 49.73	4.3575072
Wallace	194 59 05.93	15 00 12.69	4.0441422
Short	196 28 53.21	16 30 21.73	4.1261567

GUTHRIE STANDPIPE, LOGAN COUNTY.

(Not occupied.)

This standpipe was also located by the Coast Survey in 1902.

Station mark: Center of standpipe.

[Latitude 35° 52′ 38.15″. Longitude 97° 24′ 40.20″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Wingard	137 36 32	317 33 48	4.01730
Flinn			4.11035
Wallace			3.84522

LANGSTON, LOGAN COUNTY.

(Not occupied.)

Station mark: Center of main college building.

[Latitude 35° 56′ 40.7″. Longitude 97° 15′ 34.6″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Short			3.95982
Reece			3.94349
Wallace			4.05506

REECE, LOGAN COUNTY.

In the SW. ¼ SW. ¼ sec. 26, T. 17 N., R. 1 E., on cultivated land belonging to H. R. Reece and on highest ground northeast of Reece's house.

Station mark: None.

Reference marks: A bronze triangulation tablet set in sandstone rock at southeast corner of H. R. Reece's house. True azimuth to mark, 41° 52′ 30″, distance 328 feet.

[Latitude 35° 54′ 54.60″. Longitude 97° 10′ 09.09″.]

To station	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Short	75	30	20.20	255	24	50.66	4.1631739
Paradise	161	54	12.39	341	52	39.55	4.1052271
Perkins	244	04	10.20	64	10	29.72	4.2554371
Phee	254	23	54.12	74	27	42.29	4.0051680
Tryon	284	45	45.93	104	53	00.28	4.2837655
Strong							3.7728468
Cordis							4.1612354

SHORT, LOGAN COUNTY.

In the NE. ¼ sec. 5, T. 16 N., R. 1 W., on cultivated land of J. J. Mulhall, about 800 feet southeast of quarter corner on north side of said section and about 300 feet east and 50 feet north of angle of public road.

Station mark: A bronze triangulation tablet set in a sandstone rock and buried 1.5 feet in ground.

Reference marks: Iron bench-mark post set 3 feet in ground in fence corner 146.5 feet north of station.

[Latitude 35° 52′ 55.99″. Longitude 97° 19′ 31.10″.]

To station	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Flinn	16	30	21.73	196	28	53.21	4.1261567
Wallace							3.3660029
Wingard	115	49	39.44	295	43	53.93	4.2148749
Cordis	196	36	03.16	16	37	43.31	4.1747474
Paradise	212	40	14.60	32	44	11.76	4.2720807
Perkins	249	05	20.03	70	17	09.22	4.5106389
Reece	255	24	50.66	75	30	20.20	4.1631739
Strong	257	53	07.90	77	56	25.67	3.9371098

STRONG, LOGAN COUNTY.

About 800 feet west of corner to secs. 5, 6, 31, and 32, Tps. 16 and 17 N., R. 1 E. It is in wagon-road right of way about 2.5 feet north of south fence, on highest ground along line between secs. 6 and 31.

Station mark: A bronze triangulation tablet cemented in stone set flush with ground.

Reference mark: A spike in a 10-inch black-jack tree. True azimuth, 270° 50′ 40″, distant 48.3 feet.

[Latitude 35° 53′ 54.78″. Longitude 7° 13′ 53.74″.]

To station	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Short	77	56	25.67	257	53	07.90	3.9371098
Paradise	186	48	44.56	6	49	23.66	4.1477844
Reece							3.7728468

WALLACE, LOGAN COUNTY.

About 1,600 feet south of corner to secs. 7, 8, 17, and 18, T. 16 N., R. 1 W.; it is in the right of way and about 7 feet west of north-south fence on east side of right of way. The farm of J. N. Wallace is the quarter section to the west of this station.

Station mark: An iron bench-mark post set 3½ feet in the ground. Theodolite elevated 30 feet.

[Latitude 35° 51′ 46.96″. Longitude 97° 20′ 08.24″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Flinn	15	00	12.09	194	59	05.93	4.0441422
Wingard	123	50	02.73	303	44	39.08	4.2214602
Short							3.3660029

WINGARD, LOGAN COUNTY.

A Coast Survey station, established in 1902; belongs to the ninety-eighth meridian net. In the SW. ¼ sec. 14, T. 17 N., R. 3 W., on land of J. B. Wingard, about 5 miles north and 3.75 miles west of Guthrie. Station located on highest part of ground, which is gently sloping.

Station mark: A 12-inch terra-cotta pipe set in cement and filled with cement, with a 60-penny wire nail to mark center; instrument elevated 40 feet.

Reference marks: Is in southwest quarter, very near center of section, 0.94 meter south of east-west fence and 0.50 meter west of north-south fence, true azimuth 194° 22′ 03″, distant 329.096 meters; to corner stone of quarter corner between secs. 14 and 23, true azimuth 2° 04′ 56″, distant 490.9 meters.

[Latitude 35° 56′ 47.428″. Longitude 97° 29′ 20.129″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Cordis	249	13	28.56	69	20	54.83	4.3084791
Short	295	43	53.93	115	49	39.44	4.2148749
Wallace	303	44	39.08	123	50	02.73	4.2214602
Flinn	331	07	49.73	151	12	06.18	4.3575052
Edmond	356	13	07.79	176	13	56.83	4.5048513

EDMOND, OKLAHOMA COUNTY.

A Coast Survey station, established in 1902; belongs to the ninety-eighth meridian net; near the center of sec. 25, T. 14 N., R. 3 W., on land of Pete Wilderson, at northeast outskirts of village of Edmond. The station is at east edge of cultivated field about 100 meters north-northeast of highest ground and 119.60 meters south of east-west fence running to section corner.

Station mark: A 12-inch terra-cotta pipe set and filled with cement, with a 60-penny nail projecting one-fourth inch from top. Theodolite elevated 30 feet.

Reference marks: In north-south fence, true azimuth 263° 11′ 39″, distant 79.402 meters; to center of dome of Normal College, true azimuth 70° 54′ 33.9″, distant 650 meters; to cross on spire of Catholic Church, true azimuth 63° 29′ 31.6″.

[Latitude 35° 39′ 32.111″. Longitude 97° 27′ 56.292″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Wingard	176	13	56.83	356	13	07.79	4.5048513
Flinn	216	37	45.79	36	41	12.41	4.1732601

CORDIS, PAYNE COUNTY.

On land of E. D. Cordis, about 6.5 miles northwest of Coyle, in the NW. ¼ sec. 36, T. 18 N., R. 1 W.; is 60 feet northwest of highest ground.

Station mark: A bronze triangulation tablet cemented in a sandstone rock set 1½ feet in ground.

Reference mark: An iron bench-mark post set 3 feet in ground, true azimuth to mark 169° 29′ 33″, distant 53.3 feet. Theodolite elevated 20 feet.

[Latitude 36° 00′ 40.91″. Longitude 97° 16′ 40.50″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Short	16	37	43.31	196	36	03.16	4.1747474
Wingard	69	20	54.83	249	13	28.56	4.3084791
Paradise	256	09	58.82	76	12	16.03	3.7793720
Reece							4.1612354

CUSHING, PAYNE COUNTY.

About 1 mile southwest of Cushing and 1,000 feet south of corner to secs. 4, 5, 8, and 9, T. 17 N., R. 5 E.; the station is on wagon-road right of way about 3 feet from west fence.

Station mark: A bronze triangulation tablet cemented in stone set flush with the ground.

[Latitude 35° 58′ 01.21″. Longitude 96° 47′ 05.24″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Air	1	34	25.79	181	34	20.01	3.9541412
Agra	52	57	44.69	232	54	08.27	4.0638806
Perkins	96	34	07.57	276	26	54.38	4.2693782
Mound	182	07	52.34	2	08	06.82	4.2186733
Quay	195	40	32.05	15	43	03.20	4.3755682
Indian	277	54	06.35	97	59	18.32	4.1284832

CUSHING OIL TOWER, PAYNE COUNTY.

(Not occupied.)

Station mark: Center of tower.

[Latitude 35° 58′ 47.3″. Longitude 96° 46′ 52.0″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Air							4.01829
Indian							4.12673
Cushing							3.16353

CUSHING, CHRISTIAN CHURCH SPIRE, PAYNE COUNTY.

(Not occupied.)

Station mark: Center of spire.

[Latitude 35° 58′ 52.2″. Longitude 96° 46′ 11.1″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Air							4.02888
Indian							4.09472
Cushing							3.31735

INDIAN, PAYNE COUNTY.

On a bare knoll about 800 feet west and 200 feet north of center of sec. 14, T. 17 N., R. 6 E., about 600 feet northwest of the house of J. M. Branstetter, on land belonging to an Indian.

Station mark: An iron bench-mark post set 3 feet in the ground.

[Latitude 35° 57′ 00.92″. Longitude 96° 38′ 13.95″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Air	62	17	59.40	242	12	41.95	4.1855361
Cushing	97	59	18.32	277	54	06.35	4.1284832

MOUND, PAYNE COUNTY.

Near the center of northernmost of two bare mounds known as Twin Mounds, in the SW. ¼ sec. 16, T. 19 N., R. 5 E.

Station mark: A bronze triangulation tablet cemented in stone set flush with ground.

[Latitude 36° 06′ 57.65″. Longitude 96° 46′ 40.64″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Cushing	2	08	06.82	182	07	52.34	4.2186733
Agra	22	45	39.42	202	41	48.15	4.4064795
Perkins	52	57	34.49	232	50	06.05	4.3786557
Quay	222	30	48.31	42	33	05.21	3.9336897

PARADISE, PAYNE COUNTY.

In the southeast corner of the NE. ¼ sec. 20, T. 18 N., R. 1 E. (Indian meridian), about 800 feet north of south line and 600 feet west of east line of quarter section, and on highest point.

Station mark: A bronze triangulation tablet cemented in stone set flush with ground.

Reference mark: Spike in 8-inch blazed black-jack tree which bears northwest, distant 89.5 feet.

[Latitude 36° 01′ 27.53″. Longitude 97° 12′ 47.16″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Strong	6	49	23.66	186	48	44.56	4.1477843
Short	32	44	11.76	212	40	14.60	4.2726807
Cordis	76	12	16.03	256	09	58.82	3.7793720
Perkins	281	50	56.00	101	58	48.95	4.3137085
Agra							4.5089629

PERKINS, PAYNE COUNTY.

This station is the top of chimney of Union schoolhouse in district No. 55, 4 miles northeast of Perkins, in the southeast corner of the SW. ¼ sec. 33, T. 18 N., R. 3 E.

Station mark: Center of chimney. Theodolite elevated 30 feet.

[Latitude 35° 59′ 09.59″. Longitude 96° 59′ 22.64″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Phee	51	28	28.59	231	25	57.32	3.9166136
Reece	64	10	29.72	244	04	10.20	4.255[illegible]371
Short	70	17	09.22	249	05	20.03	4.5106389
Paradise	101	58	48.95	281	50	56.00	4.3137085
Mound	232	50	06.05	52	57	34.49	4.3786537
Cushing	276	26	54.38	96	34	07.57	4.2693782
Agra	314	30	17.42	134	33	53.81	4.1126523
Tryon	349	29	49.70	169	30	45.10	4.1137369

PERKINS, TALLEST CHURCH SPIRE, PAYNE COUNTY.

(Not occupied.)

Station mark: Center of spire.

[Latitude 35° 58′ 33.1″. Longitude 97° 02′ 04.4″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Phee							3.67032
Perkins							3.62390
Reece							4.14268

QUAY, PAWNEE COUNTY.

On bare point of ridge about 0.75 mile north of Quay, in the NE. ¼ sec. 36, T. 20 N., R. 5 E., about 200 feet west of north-south public road.

Station mark: A bronze triangulation tablet cemented in large limestone rock set flush with ground.

[Latitude 36° 10′ 22.87″. Longitude 96° 42′ 48.52″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Cushing	15	43	03.20	195	40	32.05	4.375582
Mound	42	33	05.21	222	30	48.31	3.933697

PRIMARY TRAVERSE.

LOGAN COUNTY.

GUTHRIE QUADRANGLE.

The following are results of a primary-traverse line between Wingard triangulation station (a station of the Coast Survey, 1903) and the Guthrie standpipe (an intersected point of the Coast Survey, 1903), run by H. H. Hodgeson, topographer, in 1905. Positions are based on the United States standard datum.

Geographic positions in Guthrie quadrangle.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Wingard triangulation station, T. 17 N., R. 3 W., in SW. ¼ sec. 14, on property of J. B. Wingard, about 5 miles north and 3.75 miles west of Guthrie	35	56	47.428	97	29	30.10
T. 17 N., R. 3 W., corner secs. 13, 14, 23, and 24	35	56	31.60	97	28	44.50
T. 17 N., Rs. 2 and 3 W., corner secs. 13, 18, 19, and 24	35	56	31.40	97	27	40.90
T. 17 N., Rs. 2 and 3 W., corner secs. 19, 24, 25, and 30	35	55	39.30	97	27	40.94
T. 17 N., R. 2 W., on line between secs. 19 and 30, south of road, 2 feet west of Mort Carey's mail box, iron post stamped "Prim. Trav. Sta. No. 17"	35	55	38.90	97	27	00.00
T. 17 N., R. 2 W., corner secs. 19, 20, 29, and 30	35	55	39.20	97	26	35.10
T. 17 N., R. 2 W., corner secs. 20, 21, 28, and 29	35	55	38.80	97	25	31.10
Center of track between two spurs of Santa Fe bridge over Cimmarron River	35	54	58.50	97	25	43.20
Guthrie astronomic pier, located in "Government acre," 51.4 feet south of building line on Oklahoma avenue and 116.5 feet east of building line on Second street; geographic position of pier by astronomic observations by S. S. Gannett, 1892	35	52	42.22	97	25	33.04
By this traverse (United States standard)	35	52	39.74	97	25	36.62
Guthrie standpipe	35	52	38.10	97	24	40.20

TEXAS-LOUISIANA.

PRIMARY TRAVERSE.

BOWIE, CASS, FANNIN, GREGG, HARRISON, LAMAR, MARION, RED RIVER, TITUS, AND UPSHUR COUNTIES, TEX.; CADDO PARISH, LA.

CLARKSVILLE, GILMER, JEFFERSON, MOUNT PLEASANT, MOUNT VERNON, PARIS, SHAWNEETOWN, AND TEXARKANA.

An area of about 5,000 square miles in the northeastern part of Texas was controlled during the winter and spring of 1904–5 by Sledge Tatum, topographer, who ran a primary-traverse line 597 miles in length. The line started from a point at Texarkana previously located by primary traverse and was run approximately along parallels and meridians bordering 30-minute quadrangles, and was tied to triangulation station Goodland, Choctaw Nation, Indian Territory. Positions are given on the United States standard datum.

CLARKSVILLE QUADRANGLE (RED RIVER AND LAUREL COUNTIES, TEX.).

Geographic positions along Texas and Pacific Railway between Clarksville and Paris.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Clarksville, street crossing at west end of station	33	37	00.9	95	03	08.4
Milepost 63	33	37	54.3	95	04	58.3
Milepost 64, 50 feet north of center of track, iron post stamped "Prim. Trav. Sta. No. 11"	33	38	23.8	95	05	50.8
Water tank	33	38	58.9	95	06	55.4
Milepost 67	33	39	28.3	95	08	36.9
Bagwell, 50 feet from center of track, street crossing at west end of station, south of track, east edge of road, iron post stamped "Prim. Trav. Sta. No. 27"	33	39	45.6	95	09	40.9
Road crossing	33	39	49.4	95	11	04.6
Milepost 70	33	39	48.1	95	11	42.1
Road crossing, 50 feet north of center of track, east edge of road, iron post stamped "Prim. Trav. Sta. No. —"	33	39	46.6	95	12	40.4
Schoolhouse, road crossing at	33	39	48.4	95	14	09.6
Milepost 73	33	39	50.0	95	14	47.2
Detroit station, at road crossing, east end of,i ron post stamped "Prim. Trav. Sta. No. 50"	33	39	44.0	95	15	57.2
Milepost 75,	33	39	38.9	95	16	53.0
Milepost 76, 50 feet south of track, iron post stamped "Prim. Trav. Sta. No. 57"	33	39	36.1	95	17	55.2
Milepost 77	33	39	34.6	95	18	57.1
Road crossing, 50 feet north of center of track, west of road, iron post stamped "Prim. Trav. Sta. No. 65"	33	39	31.4	95	20	43.1
Road crossing	33	39	33.0	95	21	43.2
Road crossing	33	39	37.0	95	22	32.5
Blossom station, iron post 300 feet east of, stamped "Prim. Trav. Sta. No. 72"	33	39	39.0	95	23	00.6
Milepost 82, road crossing	33	39	36.8	95	24	10.0
Milepost 83	33	39	34.7	95	25	12.2
Road crossing	33	39	33.0	95	26	03.4
Milepost 85	33	39	30.6	95	27	14.8
Reno flag station, road crossing, 50 feet from center of track, north edge of right of way, east edge of road, iron post stamped "Prim. Trav. Sta. No. 90"	33	39	30.1	95	27	45.5
Road crossing	33	39	26.5	95	28	38.7
Road crossing	33	39	10.9	95	29	27.5
Road crossing	33	38	56.6	95	30	12.4
Water tank, road crossing	33	38	49.2	95	30	58.2
Milepost 90	33	38	56.9	95	32	17.7
Paris, Texas and Pacific Rwy. station	33	39	01.7	95	33	24.4
Paris, crossing of Texas and Pacific Rwy. and St. Louis and San Francisco R. R	33	38	55.8	95	34	07.3

Geographic positions along highways.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Clarksville station, street crossing at west end of	33	37	00.9	95	03	08.4
Station 15, iron post stamped "Prim. Trav. Sta. No. 15"	33	34	34.7	95	02	48.5
Stanley post-office	33	33	22.0	95	02	54.9
Mail box 26	33	32	38.5	95	03	09.5
Iron post at east side of road stamped "Prim. Trav. Sta. No. 29"	33	32	07.2	95	03	14.3
Albert Bullock's mail box	33	31	27.2	95	03	12.2

GILMER QUADRANGLE (CAMP, CASS, MARION, HARRISON, GREGG, AND UPSHUR COUNTIES, TEX.).

Geographic positions along Missouri, Kansas and Texas Railway between Dangerfield and Lasater.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Hughes, also called Hughes Spring, Cass County, Coast and Geodetic Survey bench mark, the west face of a brick building owned by T. B. Keaster, in new part of building, in double column where the old and new parts join, 11 paces from the northwest corner of the building, in the twenty-first tier of brick above the concrete sidewalk, copper bolt	32	59	51.4	94	37	52.36
Dangerfield, tablet in court-house	33	01	53.3	94	43	19.30
Road crossing	32	59	43.5	94	36	42.40
Road crossing	32	59	37.4	94	36	24.10
Milepost 812	32	57	55.3	94	35	16.20
South edge of right of way, east edge of road, in angle of fence, iron post stamped "Prim. Trav. Sta. No. 210"	32	57	13.2	94	34	31.70
Road crossing at Pattengill flag station	32	56	17.7	94	34	12.70
Milepost 218	32	55	39.5	94	34	00.10
Milepost	32	54	52.4	94	33	35.50
Road crossing	32	54	14.8	94	33	31.70
Avinger, southeast edge of station, iron post stamped "Prim. Trav. Sta."	32	54	01.9	94	33	25.30
Avinger, Cass County, Coast and Geodetic Survey bench mark, 26 paces north of old track, 19 paces west of old station, 2 telegraph poles east of milepost 817, 12 paces north of public road paralleling railroad, limestone post	32	53	30.2	94	32	46.40
Marion-Cass county-line post	32	52	46.2	94	32	16.70
At private road crossing, north edge of right of way, east edge of road, iron post stamped "Prim. Trav. Sta. No. 244"	32	52	09.9	94	31	43.50
Milepost 821	32	51	15.4	94	31	45.90
Orrs flag station, road crossing	32	50	32.9	94	31	29.50
Road crossing	32	50	16.7	94	30	33.60
Lasater, Marion County, Coast and Geodetic Survey bench mark, 9 paces north of old abandoned grade, 35 paces north of new track, 10 feet east of second telegraph pole (old line), west of platform used as station, 44 paces west of railroad-crossing sign at road crossing, limestone post	32	50	05.0	94	30	12.30

Geographic positions along Texas and Pacific Railway, milepost 75 to Big Sandy.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Milepost 76, 1,950 feet west of, road crossing	32	30	33.6	94	30	19.8
Milepost 77, road crossing 2,000 feet west of	32	30	27.9	94	31	29.3
Hallsville, 1,000 feet east of station, street crossing, east of road, 24 feet south of railroad, iron post stamped "Prim. Trav. Sta. No. 137"	32	30	14.9	94	34	13.6
Lansing flag station, 36 feet north of track at west edge of road, iron post stamped "Prim. Trav. Sta. No. 149"	32	30	27.0	94	37	33.4
Road crossing 1,000 feet west of milepost 85	32	30	14.1	94	39	17.0
Milepost 87, 750 feet west of, private-road crossing	32	30	07.5	94	41	12.2
Longview Junction, 30 feet west of station, street crossing	32	29	38.4	94	43	45.7
Cattle guard west of section house, west side of guard, 21 feet west of track, iron post stamped "Prim. Trav. Sta."	32	29	45.2	94	44	42.8
Willow Springs flag station, road crossing	32	30	11.5	94	47	43.2
Road crossing at sawmill, Castleberg's spur	32	30	11.6	94	49	05.3
Camps flag station, road crossing, 40 feet north of track at west side of road, iron post stamped "Prim. Trav. Sta. No. 201"	32	30	15.3	94	51	19.9

Geographic positions along Texas and Pacific Railway, milepost 75 to Big Sandy—Cont'd.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Milepost 99	32	30	41.4	94	53	17.2
Road crossing at sawmill and spur	32	31	12.8	94	54	38.8
Gladewater, street crossing, 60 feet east of station	32	32	04.8	94	56	41.4
Milepost 103, 140 feet west of, 26 feet south of track, iron post stamped "Prim. Trav. Sta. No. 221"	32	32	14.8	94	56	58.7
Wilkin flag station, cattle guard 100 feet west of road crossing at, 40 feet north of track, iron post stamped "Prim. Trav. Sta. No. 233".	32	33	29.2	95	00	43.2
Milepost 110, 500 feet east of, road crossing	32	34	20.8	95	03	33.2
Big Sandy, crossing of Texas and Pacific Rwy. and Cotton Belt Route.	32	34	53.3	95	06	32.4

Geographic positions along St. Louis Southwestern Railway. Big Sandy to Pittsburg.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Road crossing, 32 feet east of track, in angle of fence at north side of wagon road, iron post stamped "Prim. Trav. Sta. 255"	32	35	03.0	95	06	15.1
Pinnacle flag station, road crossing at siding	32	37	32.9	95	03	48.8
Milepost 519	32	38	32.2	95	02	23.7
Road crossing, 32 feet east of track, south edge of road, iron post stamped "Prim. Trav. Sta. No. 295"	32	38	49.3	95	02	06.3
Pritchett flag station, 530 feet northeast of mail crane, road crossing..	32	39	45.4	95	01	02.9
Runaway flag station, road crossing	32	40	55.2	94	59	09.9
Road crossing	32	42	27.7	94	57	22.8
Gilmer, 1 mile south of, milepost 511, road crossing, 36 feet west of track, south edge of road, iron post stamped "Prim. Trav. Sta. No. 341"	32	43	05.3	94	56	47.5
Gilmer, street crossing at north end of station	32	43	49.7	94	56	53.0
Road crossing at switch stand	32	47	04.8	94	57	21.0
Delrose flag station, road crossing north of, 30 feet west of track, at edge of road, iron post stamped "Prim. Trav. Sta"	32	47	22.5	94	57	28.0
Bettie, 100 feet north of station, road crossing	32	48	29.4	94	57	36.2
Smith flag station, 600 feet south of, 38 feet west of track, at cattle guard, iron post stamped "Prim. Trav. Sta."	32	50	36.3	94	58	13.7
Road crossing	32	51	47.5	94	58	10.0
Road crossing at church	32	53	22.9	94	58	01.9
Road crossing, 40 feet west of track and north of road, iron post stamped "Prim. Trav. Sta."	32	55	26.2	94	58	15.9
Road crossing north of water tank	32	57	27.3	94	57	55.7
Pittsburg, crossing of Missouri, Kansas and Texas and St. Louis Southwestern Rwys	32	59	47.7	94	58	08.8

JEFFERSON QUADRANGLE (CASS, JEFFERSON, AND MARION COUNTIES, TEX.).

Geographic positions along Missouri, Kansas and Texas Railway between Avinger and Jefferson.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Road crossing at milepost	32	49	15.1	94	29	01.3
Iron post at north edge of right of way and east edge of road, stamped "Prim. Trav. Sta. No. 282"	32	49	00.7	94	27	33.0
Milepost 828	32	48	41.2	94	26	12.4
Kelleyville, Marion County, Tex., Coast and Geodetic Survey bench mark, 30 feet west of and across track from switch stand at west end of siding, between thrid and fourth telegraph poles east of milepost 830, 14 paces north of track, in an angle formed by right-of-way fence and fence crossing railroad, limestone post	32	47	19.9	94	25	01.5
At road crossing, south edge of right of way, east edge of road, iron post stamped "Prim. Trav. Sta. No. 317"	32	47	09.6	94	23	03.0
Milepost 833	32	46	45.3	94	22	23.8
Road crossing at milepost 834	32	46	07.4	94	21	47.6
Crossing of Texas Pacific Rwy	32	45	53.4	94	21	19.9
Jefferson, Marion County, Coast and Geodetic Survey bench mark, 7 feet north of telegraph pole just opposite the Missouri, Kansas and Texas Rwy. station, almost in line with east end of building and 16 paces north of track, limestone post	32	45	31.8	94	20	38.4

Geographic positions along Texas and Pacific Railway between Marshall and Bivins.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Marshall, railroad junction and street crossing under tracks	32	33	05.2	94	22	07.6
Milepost 65	32	34	25.8	94	22	00.2
Road crossing	32	38	07.8	94	21	24.6
Road crossing	32	39	07.5	94	20	51.2
Woodlawn, street crossing 60 feet south of station	32	40	02.1	94	20	35.8
Private-road crossing at section house	32	40	29.6	94	20	29.2
Milepost 55, 1,800 feet north of, road crossing	32	43	00.0	94	21	02.4
Road crossing	32	43	58.4	94	21	27.2
Milepost 53	32	44	22.0	94	21	31.3
Road crossing	32	46	08.6	94	20	34.5
Private-road crossing, at west edge of right of way, north edge of road, iron post stamped "Prim. Trav. Sta. No. 346"	32	47	35.1	94	19	50.7
Milepost 47	32	48	39.2	94	18	56.3
Road crossing, west edge of right of way, south edge of road, iron post stamped "Prim. Trav. Sta. No. 362"	32	50	20.4	94	17	54.8
Milepost 43	32	51	42.6	94	17	03.2
Road crossing	32	52	19.6	94	17	03.0
Lodi, street crossing near, east edge of right of way, south edge of road, in angle of fence, iron post stamped "Prim. Trav. Sta. No. 379"	32	52	34.1	94	16	54.1
Milepost 41	32	53	19.7	94	16	35.1
Milepost 40	32	54	09.1	94	16	22.6
Road crossing, west edge of right of way, south edge of road, iron post stamped "Prim. Trav. Sta. No. 398"	32	55	01.6	94	16	00.4
Kildare station	32	56	27.9	94	15	01.6
Station No. 411 and also station No. 527 of Malta-Kildare line	32	56	45.1	94	14	53.6
Kildare station, 0.5 mile north of	32	56	45.1	94	14	46.2
Road crossing, 600 feet north of milepost 36, iron post stamped "Prim. Trav. Sta. No. 4"	32	57	17.9	94	14	21.3
Milepost 35	32	57	57.5	94	13	52.8
Milepost 34	32	58	40.8	94	13	17.9
Water tank	32	59	42.3	94	12	35.4

Geographic positions along highways.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Tom Dodge's mail box	32	58	15.4	94	18	33.5
Road to right	32	58	00.2	94	17	53.9
Crossroads	32	57	05.1	94	15	39.0
Kildare public school, northeast corner of building lot	32	56	40.2	94	14	57.2

Geographic positions along Texas and Pacific Railway, Louisiana-Texas State line via Marshall to milepost 75.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Missouri, Kansas and Texas Rwy. crossing, 40 feet south of track, 1,000 feet east of crossing, iron post stamped "Prim. Trav. Sta. No. 77"	32	28	34.9	94	03	00.5
Waskom station, 200 feet east of, street crossing	32	28	48.1	94	03	35.4
Milepost 344, road crossing	32	29	03.3	94	05	04.3
Jonesville, 400 feet east of station, street crossing	32	29	52.7	94	06	30.2
Road crossing 1.5 miles west of Jonesville, 30 feet south of track, west edge of road, iron post stamped "Prim. Trav. Sta. No. 55"	32	30	03.1	94	08	07.9
Road crossing	32	30	06.5	94	09	08.9
Road crossing	32	30	47.2	94	11	15.7
Road crossing	32	31	20.2	94	12	57.1
Scottsville flag station, road crossing	32	32	16.8	94	14	19.7
Road crossing, iron post stamped "Prim. Trav. Sta. No. 27"	32	32	31.3	94	15	27.7
Road crossing	32	32	45.2	94	16	49.3
Milepost 359, 300 feet east of, road crossing	32	33	15.3	94	18	56.0
Road crossing, at first telegraph pole east of milepost 68. Reference mark; An iron post 40 feet south of track at east side of road, stamped "Prim. Trav. Sta. 89"	32	32	52.5	94	23	23.5
Abner flag station, road crossing, 40 feet north of track on west side of road, iron post stamped "Prim. Trav. Sta. No. 193"	32	30	38.2	94	26	08.2
Road crossing at milepost 73	32	30	28.2	94	27	11.4
Road crossing 0.25 mile west of milepost 75	32	30	57.1	94	29	23.1

MOUNT PLEASANT QUADRANGLE (BOWIE, CASS, MORRIS, AND TITUS COUNTIES, TEX.).

Geographic positions along highways, Malta to Simms.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Road to right	33	28	10.2	94	31	49.3
Crossroads	33	27	33.6	94	31	41.2
Crossroads (dim)	33	27	00.2	94	31	38.0
Simms post-office, crossroads, 6 miles from	33	26	01.4	94	31	38.0
Bridge	33	25	13.3	94	31	35.1
Anderson Creek, bridge over	33	24	08.6	94	31	34.1
Sam Linsey's house	33	23	19.5	94	31	24.8
John Harris's house, iron post 600 feet west of, stamped "Sta. No. 94".	33	22	47.6	94	31	18.8
Road to right	33	21	18.1	94	31	13.3
Simms post-office, road to left, 400 feet east of	33	20	59.1	94	30	29.8
Bridge	33	19	28.1	94	30	01.1

Geographic positions along cotton-belt route near Bassett.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Road crossing	33	19	00.6	94	29	42.4
Milepost 449	33	18	34.4	94	32	08.1
Bassett station	33	18	42.9	94	33	46.5
Road south	33	18	31.1	94	34	13.2

Geographic positions along highways.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Signboard, "Bassett 4 miles"	33	16	13.0	94	31	51.0
Sulphur River, north bank of county line	33	16	06.7	94	31	47.4
Fence, corner of	33	15	31.4	94	31	17.6
Milepost, "21 miles to Linden"	33	15	22.8	94	30	55.6
Bryans Mill post-office, 0.25 mile northwest of, iron post stamped "Prim. Trav. Sta. 248"	33	14	15.2	94	30	05.4
ALONG WEST EDGE OF QUADRANGLE.						
Greenhill post-office	33	15	32.4	94	59	59.8
Payne's store, iron post stamped "Sta. No. 178"	33	14	58.8	94	59	49.5
W. W. Smith's house, 500 feet south of, east edge of road, iron post stamped "Sta. No. 193"	33	13	17.2	94	59	20.7
Mount Pleasant, 2 miles north of, 700 feet north of creek bridge, east edge of road, iron post stamped "Prim. Trav. Sta. No. 215"	33	11	14.8	94	58	21.7
Mount Pleasant court-house, tablet	33	09	23.0	94	58	10.1

Geographic positions along St. Louis Southwestern Railway between Mount Pleasant and Pittsburg.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
St. Louis Southwestern Rwy., street crossing	33	09	11.0	94	58	08.3
Road crossing	33	08	20.2	94	58	24.5
On west edge of right of way and north side of road, road crossing, iron post stamped "Prim. Trav. Sta. No. 12"	33	07	20.3	94	58	26.6
Road crossing	33	06	14.3	94	58	15.1
West edge of right of way, 50 feet west of track at gate, iron post stamped "Prim. Trav. Sta. No. 24"	33	05	00.3	94	58	07.8
Cypress flag station, road crossing at section house 300 feet north of	33	03	37.9	94	58	08.7
North side of road, east edge of right of way, iron post stamped "Prim. Trav. Sta. No. 37"	33	02	24.5	94	58	19.7
Road crossing	33	01	21.2	94	58	15.5
Milepost 490	33	00	45.7	94	58	08.6
On west edge of right of way, iron post stamped "Prim. Trav. Sta. No. 50"	33	00	01.9	94	58	07.7
Pittsburg, crossing of Missouri, Kansas and Texas and St. Louis Southwestern Rwys	32	59	47.7	94	58	08.8

Geographic positions along Missouri, Kansas and Texas Railway between Pittsburg and Hughes.

Station.	Latitude.			Longitude		
	°	′	″	°	′	″
Pittsburg, Camp County, 0.25 mile west of station, on concrete arch culvert of Missouri, Kansas and Texas Rwy., 60 feet north of water tank, 1 telegraph pole east of milepost 786, top of coping to north side, copper bolt	32	59	46.5	94	58	26.5
Milepost 789, private road crossing 100 feet north of, north of track on edge of right of way, iron post stamped "Prim. Trav. Sta"	33	00	42.4	94	55	34.6
Flag station, road crossing	33	00	53.8	94	54	11.5
Camp-Titus county line, 50 feet south of track, iron post stamped "Prim. Trav. Sta. No. 75"	33	01	05.0	94	52	35.2
Milepost 793	33	01	28.0	94	51	36.8
150 feet east of road crossing on south edge of right of way, iron post stamped "Prim. Trav. Sta. No. 93"	33	01	43.4	94	50	03.5
Carson-Titus county line, Coast and Geodetic Survey bench mark, 15 paces south of track, in an angle of fence on west side of road crossing, 7 telegraph poles west of station, 5 feet from south and east fences, limestone post 36 by 6 by 6 inches	33	02	10.8	94	49	06.7
Milepost 798	33	01	49.5	94	46	57.7
South edge of right of way, east edge of road, iron post stamped "Prim. Trav. Sta. No. 118"	33	01	32.9	94	45	52.4
Road crossing	33	01	22.3	94	45	17.5
Road crossing	33	01	31.1	94	43	44.0
Dangerfield, tablet in court-house	33	01	53.3	94	43	19.4
Road crossing	33	01	55.8	94	42	06.0
Milepost 805	33	00	58.4	94	40	54.3
Road crossing	33	00	50.4	94	40	42.3
Veals flag station, crossroads at north edge of right of way, iron post stamped "Prim. Trav. Sta. No. 171"	33	00	42.7	94	40	06.7
County-line post	33	00	19.3	94	39	14.5
Hughes, also called Hughes Spring, Cass County, Coast and Geodetic Survey bench mark, in west face of a brick building owned by T. B. Keaster, in new part of building, in the double column where the old and new parts join, 11 paces from northwest corner of building and in twenty-first tier of brick above the concrete sidewalk, copper bolt	32	59	51.4	94	37	52.5

MOUNT VERNON QUADRANGLE (RED RIVER AND TITUS COUNTIES, TEX.).

Geographic positions along highways.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Cuthand Creek bridge, south end of, road to right	33	29	57.60	95	03	12.8
East edge of road, iron post stamped "Prim. Trav. Sta. No. 59"	33	28	41.20	95	03	19.4
Cuthand post-office	33	28	02.90	95	03	21.3
Cuthand, 2,100 feet south of, road to right	33	27	43.50	95	03	23.5
Crossroads, iron post stamped "Prim. Trav. Sta. No 69"	33	27	17.05	95	03	20.6
Dim road to left	33	25	37.20	95	03	38.4
East edge of road, iron post stamped "Prim. Trav. Sta. No. 86"	33	24	36.50	95	03	53.3
County line, northeast end of Sulphur bridge	33	23	24.30	95	03	46.5
Opposite new house, iron post stamped "Prim. Trav. Sta. No. 109"	33	21	37.90	95	03	49.9
Mount Pleasant, milepost 13 from, 300 feet north of, iron post stamped "Prim. Trav. Sta. No. —"	33	19	47.50	95	02	09.4
White Oak Creek, north bank	33	18	37.50	95	01	24.2
South of White Oak Creek, on summit of ridge, west edge of road, iron post stamped "Prim. Trav. Sta. No. 154"	33	17	34.60	95	00	45.8

PARIS QUADRANGLE (FANNIN AND LAMAR COUNTIES, TEX.).

Geographic positions along St. Louis and San Francisco Railroad between Paris, Tex., and Goodland, Ind. T.

Station.	Latitude.			Longitude.		
TEXAS.						
	°	′	″	°	′	″
Paris, crossing of Texas and Pacific Rwy. and St. Louis and San Francisco R. Rs	33	38	55.8	95	34	07.3
Paris station, Frisco street crossing at north end of	33	39	39.6	95	34	03.3
Road crossing	33	40	12.3	95	34	03.8
Road crossing, iron post stamped "Prim. Trav. Sta. No. 18," south of road, 50 feet east of center of track	33	41	39.7	95	33	22.7
Road crossing	33	43	09.1	95	33	12.0

Geographic positions along St. Louis and San Francisco Railroad between Paris, Tex., and Goodland, Ind. T.—Continued.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
TEXAS—continued.						
Hinckley flag station, road crossing, at angle of fence at east edge of right of way, north edge of road, iron post stamped "Prim. Trav. Sta. No. 28," 50 feet east of center of road	33	44	18.6	95	32	55.2
Road crossing, east edge of right of way and south edge of road, iron post stamped "Prim. Trav. Sta. No. 40," 50 feet east of center of track	33	47	22.1	95	31	50.5
Lenoir flag station, road crossing, 30 feet west of track, north side of road, iron post stamped "Prim. Trav. Sta. No. 45"	33	48	43.7	95	31	24.0
Store, road crossing at	33	50	08.5	95	30	55.2
Arthur station, road crossing south of	33	52	07.7	95	30	16.8
INDIAN TERRITORY.						
Bridge, north end of, on abutment, 15 feet east of center of track, tablet	33	52	39.0	95	30	02.8
Milepost 567, road crossing at	33	53	44.1	95	29	36.8
Milepost 565	33	55	25.1	95	30	12.6
Grant station, road crossing 400 feet south of	33	56	25.3	95	30	34.7
Hugo, crossing Choctaw R. R	34	00	30.4	95	30	54.1
Goodland flag station, road crossing at	34	02	53.7	95	31	42.6
Road crossing (line turns west on wagon road)	34	03	18.1	95	32	03.6
Goodland triangulation station, on a high flat prairie ridge owned by Tom Self, 4 miles west of Goodland. From quarter corner between secs. 1 and 2, T. 6 S., R. 16 E., station bears S. 79° 25′ W., distant 11.68 chains. Station mark: Shell rocks piled around foot of tall signal pole	34	03	43.0	95	35	36.3

SHAWNEETOWN QUADRANGLE (BOWIE AND RED RIVER COUNTIES, TEX.).

Geographic positions along Texas and Pacific Railway between Malta and Clarksville.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Road crossing, on north line of right of way, iron post stamped "Prim. Trav. Sta. No. 103"	33	29	15.3	94	31	19.0
Milepost 30	33	29	40.7	94	32	47.4
Road crossing, 60 feet north of track, iron post stamped "Prim. Trav. Sta. No. 113"	33	30	05.3	94	34	08.9
Road crossing	33	30	18.3	94	36	33.4
De Kalb station, street crossing 70 feet west of	33	30	29.3	94	36	59.6
De Kalb station, 1,980 feet west of, on north side of track, iron post stamped "Prim. Trav. Sta. 128"	33	30	38.3	94	37	19.4
Road crossing	33	30	57.5	94	38	08.1
Milepost 38	33	31	49.0	94	40	35.1
Oak Grove, 840 feet east of, north side of right of way, iron post stamped "Prim. Trav. Sta. No. 143"	33	32	02.9	94	41	05.2
Milepost 40	33	32	37.8	94	42	25.6
North side of track, west side of road, at road crossing, iron post stamped "Prim. Trav. Sta. No. 149"	33	32	43.7	94	42	37.4
Milepost 42	33	33	17.2	94	44	19.2
Sixty feet north of track, on west side of road crossing, iron post stamped "Sta. 160"	33	33	10.1	94	45	20.1
Avery station, street crossing 50 feet west of	33	32	58.1	94	46	50.2
Milepost 46	33	32	59.5	94	48	24.9
Road crossing, north side of track and east of road, iron post stamped "Prim. Trav. Sta. No. 174"	33	33	20.4	94	49	07.8
Road crossing	33	33	59.5	94	50	43.7
North of track, west of road crossing, iron post stamped "Prim. Trav. Sta. 186"	33	34	18.9	94	52	16.9
Road crossing	33	34	28.0	94	53	22.3
Anona station, 800 feet east of, 60 feet north of track, iron post stamped "Prim. Trav. Sta. No. 195"	33	34	47.6	94	54	30.9
Private-road crossing, north of track and west of road, iron post stamped "Prim. Trav. Sta. No. 203"	33	35	31.3	94	57	00.3
Milepost 256	33	35	52.5	94	58	09.1
Road crossing under bridge 288	33	36	09.3	94	59	02.2
Road crossing	33	36	18.5	94	59	43.5
Road crossing, north of track and east side of road, iron post stamped "Prim. Trav. Sta. 219"	33	36	41.1	95	01	29.7
Clarksville, east edge of, north of track, at road crossing, iron post stamped "Prim. Trav. Sta. No. 225"	33	36	56.7	94	02	46.1
Clarksville, west end of station, street crossing	33	37	00.9	94	03	08.4

TEXARKANA QUADRANGLE (BOWIE AND CASS COUNTIES, TEX.; CADDO PARISH, LA.).

Geographic positions along Texas and Pacific Railway.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Texarkana, crossing of Texas and Pacific and Kansas City Southern Rwys	33	25	02.36	94	03	07.8
Milepost 2	33	25	26.92	94	04	31.1
Road crossing (grade)	33	25	51.3	94	05	52.8
Junction station (operator's window)	33	26	20.5	94	07	30.1
Road crossing (grade)	33	26	30.3	94	08	14.6
Iron bench-mark post stamped "Prim. Trav. Sta. 23"	33	26	44.9	94	09	26.0
Road crossing	33	26	54.0	94	10	04.0
Leary post-office, road crossing west of	33	27	32.8	94	12	25.7
Milepost 12	33	27	46.6	94	14	30.7
Milepost 14	33	27	58.2	94	16	36.2
Hooks station, 50 feet west of, iron post stamped "Prim. Trav. Sta. 52"	33	27	56.4	94	17	23.4
Milepost 16	33	27	51.9	94	18	40.3
Milepost 18	33	27	45.3	94	20	45.8
Road crossing	33	27	41.5	94	21	57.0
Milepost 21	33	27	35.2	94	23	51.8
New Boston station, street crossing at east end of	33	27	32.6	94	24	41.2
New Boston station, iron post at road crossing, 0.5 mile west of, stamped "Prim. Trav. Sta. 83"	33	27	33.5	94	25	24.5
Milepost 25	33	28	14.7	94	27	53.5
Road crossing	33	28	37.3	94	29	10.7
Malta, Norman's store, iron post 300 feet east of, stamped "Prim. Trav. Sta. 103"	33	29	15.3	94	31	19.0

Geographic positions along Texas and Pacific Railway between Bivins and Texarkana.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Bivins, road crossing 125 feet south of, iron post stamped "Prim. Trav. Sta. No. 25"	33	01	12.8	94	11	55.4
Milepost 29	33	02	31.3	94	11	02.3
Road crossing under track	33	04	00.5	94	10	50.7
Milepost 26	33	05	03.8	94	10	34.7
Atlanta, Main street crossing	33	06	50.6	94	09	55.8
Milepost 23	33	07	31.6	94	09	33.6
Tank, road crossing 1,000 feet north of	33	08	43.3	94	09	11.2
Queen City station, street crossing north of	33	09	02.6	94	09	01.9
Road crossing	33	09	47.4	94	08	59.5
Tenark flag station, road crossing	33	10	56.6	94	09	06.8
Road crossing	33	12	50.4	94	08	10.8
Section house No. 40, tool house	33	13	25.6	94	08	09.9
Springdale flag station	33	14	00.1	94	06	03.9
Alamo post-office, road crossing, iron post stamped "Prim. Trav. Sta. No. 107"	33	15	56.1	94	06	48.3
Milepost 11	33	16	36.0	94	05	21.0
Sulphur Bridge, water tank at north end of	33	18	00.7	94	03	39.8
Railroad station	33	18	28.3	94	03	24.3
Road crossing	33	19	22.3	94	03	23.5
Road crossing	33	20	07.4	94	03	28.4
Road crossing	33	20	22.5	94	03	30.2
Milepost 4, road crossing 60 feet north of	33	22	01.1	94	03	41.2
Road crossing	33	22	46.8	94	03	46.2
Crossing of Kansas City Southern and Texas and Pacific Rwys	33	23	23.3	94	03	43.0
Texarkana, crossing of Kansas City Southern and Texas and Pacific Rwys	33	25	02.4	94	03	07.8

Geographic positions along highways.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Linden, milepost 18 miles from	33	13	23.2	94	29	41.4
Crossroads	33	12	48.5	94	29	11.3
Maple and Douglasville roads, intersection of	33	11	41.8	94	29	04.1
Road to left	33	11	40.9	94	28	33.0
Cusseta post-office, 60 feet south of	33	09	42.7	94	27	27.1
Linden, at crossroads 9 miles north of, iron post stamped "Prim. Trav. Sta. No. 341"	33	07	08.8	94	25	18.6
Crossroads	33	06	15.9	94	25	27.5
Linden, milepost 6 miles from	33	05	01.1	94	24	38.6
W. N. Anderson's house	33	04	45.1	94	24	27.3
Crossroads	33	03	09.8	94	23	49.5
Road to right	33	02	45.5	94	23	49.3
Linden, milepost 2 miles from	33	01	49.3	94	23	18.1
Linden court-house, bench-mark post at northeast corner of yard, stamped "Prim. Trav. Sta. No. 429"	33	00	39.8	94	21	52.8
Road to right	33	00	19.0	94	21	34.3

Geographic positions along Kansas City Southern Railway between Rodessa and Bloomburg.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Rodessa station, 740 feet south of, road crossing at section house, 30 feet west of track, on north side of road, iron post stamped "Prim. Trav. Sta. No. 286"	32	58	10.4	93	59	37.4
Station 293, sawmill, flag station, road crossing	33	00	04.9	94	00	42.0
Station 298, State line Arkansas and Louisiana, road crossing. Reference mark: Iron post at corner of fence west of track	33	01	09.7	94	01	18.6
Milepost 514	33	02	40.6	94	02	09.9
Ravana flag station, 60 feet south of crossing, 35 feet west of track, iron post stamped "309"	33	03	58.7	94	02	29.0
Section house No. 73	33	05	07.8	94	02	27.7
Arkansas-Texas State line, 50 feet east of track, iron post stamped "Prim. Trav. Sta. No. 320"	33	06	30.4	94	02	35.1

Geographic positions along Kansas City Southern Railway between Bloomburg and Atlanta.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Bloomburg station, 300 feet north of, 35 feet south of track, west side of road. Iron post stamped "Prim. Trav. Sta."	33	08	16.3	94	03	38.2
Road crossing 2.5 miles southwest of Bloomburg	33	08	05.0	94	04	51.1
Road crossing	33	08	11.1	94	06	34.1
Road crossing, 19 feet north of track, at west edge of road, iron post stamped "Prim. Trav. Sta. No. 349"	33	08	13.4	94	07	32.8

UTAH-NEVADA.

TRIANGULATION STATIONS.

BEAVER, IRON, AND PIUTE COUNTIES, UTAH; LINCOLN COUNTY, NEV.

IRON SPRINGS SPECIAL QUADRANGLE.

In the fall of 1905 Fred McLaughlin, assistant topographer, occupied seven new triangulation stations, based on Pioche and Tushar stations of the Coast and Geodetic Survey.

BLUE, BEAVER COUNTY, UTAH.

On the highest and most prominent peak of the Blue Mountains, about 12 miles north of Lund railroad station.

Station mark: A triangulation tablet cemented in solid rock.

[Latitude 38° 30′ 42.19″. Longitude 113° 26′ 04.25″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Tushar	276	13	22.0	96	51	31.9	4.9534284
Hot	326	42	56.5	146	48	10.0	4.3487240
Peak							4.6893173
Springs							4.6399762
Iron							4.7707540
Frisco Peak							4.5946790

FRISCO PEAK, BEAVER COUNTY, UTAH.

On Quartzite Hill, a prominent timbered peak about 4 miles north of Frisco railroad station.

Station mark: A tablet cemented in solid rock.

[Latitude 38° 47′ 33.66″. Longitude 113° 09′ 33.64″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Hot	13	19	29.1	193	14	26.0	4.7085103
Tushar	302	13	56.8	122	41	55.6	4.8874153
Granite							4.6432765
Blue							4.5946789

GRANITE, BEAVER COUNTY, UTAH.

On the highest part of sharp granite range 10 miles east of Milford railroad station. Can be approached only from the west. About 600 feet north of this point is a sharp, isolated, and inaccessible rock, located by the United States Coast and Geodetic Survey, called Milford Needle.

Station mark: A triangulation tablet cemented in solid rock.

[Latitude 38° 30′ 55.48″. Longitude 112° 47′ 54.31″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Tushar	287 23 29.8	107 37 55.4	4.5486284
Hot	66 22 44.6	246 04 14.8	4.6750857
Frisco Peak			4.6432765

HOT, IRON COUNTY, UTAH.

On the southernmost and most prominent point of the Hot Springs Mountains, about 15 miles northeast of Lund railroad station.

Station mark: A triangulation tablet set in stone and covered by a cairn 4 feet high.

[Latitude 38° 20′ 36.71″. Longitude 113° 17′ 39.82″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Springs	4 37 15.70	184 36 02.2	4.5563142
Iron	356 03 36.25	176 05 03.0	4.6987596
Blue	146 48 10.00	326 42 56.5	4.3487240
Frisco Peak	193 14 26.00	373 19 29.1	4.7095103
Granite	246 04 14.80	66 22 44.6	4.6750857
Tushar	263 28 56.80	84 01 49.3	4.8896770
Pioche	59 22 13.80	238 54 10.0	4.8880691
Peak			4.5313362

IRON, IRON COUNTY, UTAH.

On Iron Mountain, a prominent peak about 16 miles west-southwest of Cedar City post-office, on the highest part of a large iron rock. Fifteen feet west (true) of the geodetic point a rock cairn 4 feet high was built over a triangulation tablet set in solid rock.

[Latitude 37° 53′ 39.63″. Longitude 113° 15′ 19.28″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Peak	205 12 50.0	25 16 24.1	4.2992595
Springs	155 38 22.1	335 35 42.5	4.1858920
Hot	176 05 03.0	356 03 36.2	4.6987596
Pioche	98 32 56.9	278 03 35.1	4.8494989
Blue			4.7707542

PEAK, IRON COUNTY, UTAH.

On the sharpest of the Three Peaks, about 11 miles west of Cedar City post-office and 2 miles north of Iron Springs.

Station mark: A tablet cemented in solid rock, over which a cairn was erected.

[Latitude 38° 03′ 23.98″. Longitude 113° 09′ 31.23″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Iron	25	16	24.1	205	12	50.0	4.2992586
Hot	159	34	07.2	339	29	05.1	4.5313362
Blue							4.6893173
Springs							4.1862740

SPRINGS, IRON COUNTY, UTAH.

On the easternmost and highest of three peaks about 20 miles south-southwest of Lund railroad station.

Station mark: A tablet cemented in a rock, over which a cairn 4 feet high was erected.

[Latitude 38° 01′ 12.87″. Longitude 113° 19′ 38.72″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Hot	184	38	02.2	4	37	15.7	4.5563142
Iron	335	35	42.5	155	38	22.1	4.1858920
Blue							4.6399761
Peak							4.1862739

TUSHAR, PIUTE COUNTY, UTAH.

A Coast Survey station of 1882, on summit of northernmost of the highest of three peaks in Tushar Range, the backbone of which forms the boundary between Beaver and Piute counties; the peak is locally known as Mount Belknap. Can be reached most easily from Marysville, a village on upper Sevier River, 10 miles distant in an air line.

Station mark: A ⅜-inch copper bolt leaded in solid rock, around and over which was built a stone foundation pier for theodolite, with a stone slab with a drilled hole in its top. Top of copper bolt is 11¼ inches below hole in slab. The vertical-circle station is almost due north 34.12 feet from station mark. Circular stone walls around these stations were left standing. The wall around station mark, 11 feet interior diameter, 2.5 feet thick, and 4.5 feet high, is concentric with station bolt and makes an excellent reference mark in the absence of usual drill holes, which were not made owing to the loose condition of the shale rocks about the station.

[Latitude 38° 25′ 10.31″. Longitude 112° 24′ 42.96″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Hot	84	01	49.3	263	28	56.8	4.8896770
Granite	107	37	55.4	287	23	29.8	4.5496284
Frisco Peak	122	41	55.6	302	13	56.8	4.8874153
Blue	96	51	31.9	276	13	22.0	4.9534284
Pioche	71	59	46.3	250	58	56.1	5.1802173

PIOCHE, LINCOLN COUNTY, NEV.

A station of the Coast Survey, located on the highest rock knoll of a peak in the mountains east of Eagle Valley. Peak is about 1,000 feet west of boundary line between Nevada and Utah and bears N. 80° 25′ E., distant 22.5 miles (about 33 miles by road) from the courthouse in Pioche. The geodetic point is marked by a ½-inch copper bolt leaded in solid rock in the center of a stone foundation pier for theodolite as a subsurface mark. The pier is covered by a stone slab with a ¾-inch drill hole in its center as a surface mark. The copper bolt is 8¾ inches below top of drill hole. The vertical-circle station bears N. 26° 20′ E., distant 69.23 feet from geodetic point, and both points were surrounded with circular stone walls which were left standing.

Reference marks: Five drill holes, one N. 34° 28′ E., distant 8.27 feet; one S. 88° 22′ E., distant 7.91 feet; one S. 15° 14′ E., distant 8.92 feet; one N. 88° W., distant 7.71 feet, and one N. 28° 57′ W., distant 6.56 feet from geodetic point.

[Latitude 37° 59′ 10.90″. Longitude 114° 03′ 04.82″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Wheeler Peak	168	26	35.00	348	16	48.08	5.05423265
Tushar	250	58	56.09	71	59	46.26	5.18021727
Hot	238	54	10.00	59	22	13.80	4.88806910
Iron	278	03	35.10	98	32	56.90	4.84949890

WYOMING.

TRIANGULATION STATIONS.

BIGHORN, FREMONT, AND NATRONA COUNTIES.

ALCOVA, BROKEN HORN, LOST CABIN, NOWOOD, NOWATER, AND WATROUS QUADRANGLES.

During the season of 1905 T. M. Bannon, topographer, extended triangulation from the stations Broken Horn, Shepherd, and Reef, in the vicinity of Casper, Wyo., established by Sledge Tatum, topographer, from the Coast and Geodetic Survey stations Morrison and Table Mound in Colorado, northwestward to stations Deranch and Mahogany, established by Mr. Robertson from the Ranchester base and Sheridan position. The differences of the positions and bases are noted in the description for Mahogany.

Positions are given on the United States Standard datum.

DERANCH, BIGHORN COUNTY.

On the most prominent peak of Lyesite Mountain at the head of Lake Creek, a tributary of Kirby Creek. Road goes up one fork of Bridger Creek almost to station. Deranch post-office is about 7 miles south of station. Peak is timbered on the Lake Creek side and smooth and grassy on the Bridger Creek side. Water in both creeks.

Signal: A rock cairn 8 feet high, built around small pine.

Station mark: A bronze triangulation tablet set in stone which was placed in ground under center of signal.

[Latitude 43° 34′ 03.42″ (43° 34′ 05.67″[a]). Longitude 107°[a] 44′ 05.57″ (107° 44′ 03.23″[a]).]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Copper	42	11	07.23	222	04	57.40	4.2549762
Cottonwood Pass	311	39	39.47	131	46	49.18	4.2737525
Canyon [a]	72	06	05.85	251	47	08.90	4.5911836
Kirby [a]	112	55	33.71	292	44	11.96	4.3811117
Honeycomb[a]	199	25	15.59	19	29	28.37	4.3956133
Mahogany[a]	254	14	08.07	74	29	11.35	4.4843181

[a] From Ranchester base.

MAHOGANY, BIGHORN COUNTY.

On highest point of Mahogany Butte, a prominent spur from the main mountain, forming a perpendicular bluff on the side of No Wood Creek, about 5 miles down the creek from No Wood post-office. Road from No Wood to Redbank and Big Trails passes directly under station. Take this road from No Wood post-office to a point where it crosses a creek on a bridge, then take trail to right.

Station mark: A bronze triangulation tablet cemented in solid rock, over which a cairn 8 feet high is centered.

[Latitude 43° 38′ 29.83″ (43° 38′ 32.10″ [a]). Longitude 107° 22′ 16.20″ (107° 22′ 13.57″ [a]).]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Deranch	74	29	03.28	254	14	00.31	4.4842345
Deranch [a]	74	29	11.345	254	14	08.074	4.4843181
Cottonwood Pass	36	39	15.13	216	31	23.01	4.4117437
Honeycomb[a]	125	58	26.19	305	47	36.38	4.4145173

[a] From Ranchester base.

COPPER, FREMONT COUNTY.

On a high grassy hill of the Bridger Mountains between the forks of Little or Dry Bridge Creek and West Bridge Creek on the north and the drainage of Dry Creek on the south, 5 miles west of Deranch and 2 miles west of Deranch Pass. Station is on rim of Wind River Basin and visible for a great distance. Easily reached from north. A big lone pine near station distinguishes the hill.

Station mark: A bronze triangulation tablet cemented into a large stone buried flush with ground and centered under a small rock monument and tripod signal.

Reference marks: Top of two nails driven into a blazed place 6 feet above ground in a big pine tree 42.05 feet southeast of station.

[Latitude 43° 26′ 51.19″. Longitude 107° 53′ 02.773″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Badwater	111	38	45.88	291	16	53.32	4.6650032
Round Hill	144	12	08.09	324	00	20.15	4.5985699

HERDER, FREMONT COUNTY.

(Not occupied.)

A sheep herder's monument on a hill south of the stage road about one-half way between Round Hill and the Buck Camp.

[Latitude 43° 05′ 22.67″. Longitude 107° 35′ 00.50″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Round Hill	171	33	14.8	351	32	40.6	3.8867036
Poison	225	28	23.0	45	30	49.6	3.8325969

POISON, FREMONT COUNTY.

On a small hill known as Round Hill, on the south side of Poison Creek, about 500 feet southwest of Round Hill stage station, at the junction of the Casper-Lander road and the Casper-Thermopolis stage road and telephone line. The station is near the Fremont-Natrona county line.

Station mark: A bronze tablet cemented into a large bowlder buried several inches under ground, over which a mound of dirt was thrown.

Reference mark: A small hole picked into a rock buried 14.7 feet west.

[Latitude 43° 07′ 57.16″. Longitude 107° 31′ 25.97″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Round Hill	115	31	39.6	295	28	38.6	3.8211898
Badwater	217	26	31.9	37	33	32.7	4.3576638

ROUND HILL, FREMONT COUNTY.

On a sand hill on the divide between Poison and Alkali creeks, about 3 miles northwest of Round Hill stage station at forks of Lander-Casper road and Casper-Lost Cabin-Thermopolis stage road. Station is in view for a long distance from both roads. Good grass and bad water in Poison Creek bottom.

Station mark: A bronze tablet cemented into a large bowlder buried under a quadripod signal and a rough rock monument.

Reference mark: A chiseled cross on a limestone ledge 45 feet east.

[Latitude 43° 09′ 29.59″. Longitude 107° 35′ 50.58″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Badwater	232	24	53.63	52	34	55.74	4.3980635
Jack Pot	247	25	44.92	67	42	36.96	4.5573268
Reservoir	295	22	36.78	115	30	36.43	4.4560907

BADWATER, NATRONA COUNTY.

On grassy ridge on divide between Dry or South Fork of Badwater Creek and the drainage of Alkali Creek, 3 miles northeast of Cedar Pass (also known as Davis or Bostleman Pass), 3 miles east of Bostleman's ranch at forks of North and Dry Forks of Badwater Creek, 20 miles northwest of Walton, and 20 miles northeast of Lost Cabin. The road up Dry Fork of Badwater Creek passes one-half mile north of station. Good road from Walton to Bostleman via Cedar Pass; from Lost Cabin take old Bates road east to intersection with Cedar Pass road. Station is not on highest point, but 1,000 feet west and 50 feet lower. A large rock monument was also built on highest point.

Station mark: A bronze tablet cemented into a solid rock, over which a big cedar tree and rock monument were centered.

Reference mark: A chiseled cross on a large rock 32 feet west.

[Latitude 43° 17′ 42.94″. Longitude 107° 21′ 11.44″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Jack Pot	276	05	58.26	96	12	48.78	4.1327726
Reservoir	347	50	49.07	167	53	48.22	4.4494094

CLARK, NATRONA COUNTY.

On the high north end of a grassy-topped ridge, fringed on slopes with trees and locally known as Pine Mountains, 5 miles south of Clark's and 7 miles southwest of Johnson's ranches, on Casper-Lander stage road. A road from Clark's ranch to top of mountain passes 200 feet east of signal. Fine grass all over the top of mountain, and water in spring at head of gulch 500 feet west of signal.

Station mark: A bronze tablet cemented in solid rock, over which are centered a small monument and a tripod signal.

Reference mark: A small hole picked into a flat rock buried 41 feet east of signal near a small pile of stone.

Latitude 42° 58′ 28.44″. Longitude 106° 52′ 25.09″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Easy	207 56 26.76	28 01 39.72	4.3444672
Reef	292 54 04.06	113 04 45.68	4.3655294

COTTONWOOD PASS, NATRONA COUNTY.

On highest point of limestone hill on the east side of Cottonwood Pass, about 1 mile southeast of telephone line in pass, 15 miles north of Lost Cabin and same distance south of Nowood post-office. The stage from Lost Cabin to Nowood and Bonanza comes up Cottonwood Creek from Lost Cabin and passes 1 mile west of signal. There is a good spring and grass in Cottonwood Creek at fork of a road to west 1 mile south of saddle. The road to the west intersects the main road from Nowood to Deranch. Hanson's ranch, on the stage road down Nowood Creek, is 7 miles north.

Station mark: A bronze tablet cemented under a quadripod signal into the solid limestone ledge.

Reference mark: An arrow pointing to a triangle chiseled into the limestone rock 29 feet southwest of station.

[Latitude 43° 27′ 18.39″. Longitude 107° 33′ 41.45″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Round Hill	5 03 17.02	185 01 48.45	4.5199818
Copper	88 16 09.47	268 02 50.78	4.4170584

EASY, NATRONA COUNTY.

On the rim between Powder River and North Fork of Casper Creek, about 10 miles from both Clark's and Johnson's road ranches, on the Casper-Lander stage road. A wash leads from both of the ranches to the rim, which it follows around to Ballard's shearing pens, on the Casper-Kaycee wagon road.

Station mark: A bronze tablet cemented into a large bowlder buried under a small pile of rock, over which is centered a quadripod signal.

Reference mark: A chiseled square on a sandstone ledge, which is on the edge of the rim 30 feet west.

[Latitude 43° 09′ 00.98″. Longitude 106° 44′ 46.73″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Broken Horn	163 19 11.51	343 16 08.63	4.3212603
Shepherd	249 20 21.30	69 23 55.64	3.8787358
Reef	338 59 27.90	159 04 57.86	4.4858270

ENOCH, NATRONA COUNTY.

On a badland hill on divide between Keg Springs Creek and Jack Pot Fork of Powder River, about 5 miles northwest of Keg Springs station, 7 miles east of Walton, and 5 miles north of the reservoir at the head of Keg Springs Creek. The signal is in view of the Casper-Lander road for a long distance. The road from the springs stage station to Jack Pot ranch crosses the divide about 3 miles west of signal.

Station mark: A bronze tablet cemented into solid rock under a small rock monument and a quadripod signal.

Reference mark: A chiseled square on the brown rock-ledge extending east of station.

[Latitude 43° 06′ 05.95″. Longitude 107° 09′ 47.91″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Easy	260 48 49.5	81 05 55.7	4.5360627
Clark	300 47 01.1	120 58 52.8	4.4394288

JACK POT, NATRONA COUNTY.

On a high hill on divide between Buffalo Creek to north and E. K. Creek and Poison Creek drainage to southeast, 1 mile southeast of E. K. Pass and the forks of the road to the Buffalo shearing pens, on the high south end of the Bighorn Mountains, from main stage road from Walton to Houck and Kaycee; about 7 miles north of Jack Pot ranch, which is at crossing of the Lost Cabin-Casper road (known as Bates road) and the stage road from Walton to Houck and Kaycee; about 15 miles northeast of Walton.

Station mark: A bronze tablet cemented into a sand rock, over which a tree and large sandstone monument were centered.

Reference mark: A nail driven into the sandstone ledge 36 feet west.

[Latitude 43° 16′ 55.76″. Longitude 107° 11′ 12.73″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Reservoir	16 18 23.00	196 14 32.55	4.4338522
Clark	323 10 23.50	143 23 14.39	4.6297172

RESERVOIR, NATRONA COUNTY.

Near the center of the north edge of a mesa on the divide between Powder River and Poison Creek at the south head of Keg Springs Creek, 4 miles southwest of Keg Springs stage station, 6 miles south of Walton, and 3 miles south of reservoir at the head of Keg Springs Creek. The station is in sight from Casper-Lander stage road for a long distance. Water at Keg Springs, Reservoir, and Walton. Proposed extension of Chicago and Northwestern Railway from Casper west will pass in a saddle just north of signal.

Station mark: A bronze tablet cemented into a large bowlder buried under a rock, over which a quadripod signal was erected.

Reference mark: The top of a flat iron pin driven in the ground 35 feet southeast of signal.

[Latitude 43° 02′ 51.07″. Longitude 107° 16′ 49.50″.]

To station—	Azimuth.			Back azimuth.			Log. distance.
	°	′	″	°	′	″	*Meters.*
Easy	255	06	31.20	75	28	25.01	4.6528045
Clark	283	35	32.08	103	52	11.07	4.5332884

INDEX.

A.

Page.

Abbott, Ark 10
Abner, Tex 220
Adamstown, Pa 97
Agra quadrangle, Okla., triangulation in 205–216
Agra stations, Okla 205–206
Air station, Okla 206
Alabama, traverse in 2–5
Alabama and Vicksburg Railway 51, 53, 54, 56
Alamillo station, N. Mex 204
Alamo, Tex 224
Albuquerque station, N. Mex 197, 203
Alcova quadrangle, Wyo., triangulation in 229–235
Alleghenyville, Pa 97
Alma, Ark 7
Alpha, Ky 33
Alula Mills, N. C 65
Amargosa region, Cal.-Nev., triangulation in 141–155
Anabel, Mo 60
Anchorage, Ky 19, 38
Anderson, Mich 46
Anderson Creek, Tex 221
Andesite station, Nev 144
Anona, Tex 223
Antioch, Tenn 99
Antwerp, Ohio 70
Arbuckle station, Cal 122
Arkansas, traverse in 6–10
Arkansas-Indian Territory boundary 7, 9
Arlington, N. C 65
Arnoldsburg quadrangle, W. Va., triangulation stations in 106–116
Arthur, Tex 223
Ash, Mo 59
Ashland, Ill 13
Ash station, Cal 122–123
Ashwood, Ohio 73
Ashippum, Wis 120
Atlanta, Mo 58
Atlanta, Tex 224
Atlanta and West Point Railroad 3
Atlanta quadrangle, Mo., traverse in 58
Auburn, Ala 4
Auburn, Ark 8
Auburn, Mich 50
Autcliff, Mich 46
Avery, Tex 223
Avery station, Okla 206
Avinger, Tex 218
Avoca, Ky 38

B.

Page.

Bachmanville, Pa 94
Bacon Run, Ohio 71
Badwater station, Wyo 232
Bagdad, Ky 36
Bagwell, Tex 217
Bailey, Ohio 83
Bald Knob station, Va 104
Baldwin, H. L., jr., work of 178
Baldy station, Cal 166
Ball station, W. Va 112
Baltimore and Ohio Railroad 73, 75, 77, 82, 86, 87, 90
Baltimore and Ohio Southwestern Railroad 81
Baptist Corners, Ohio 87
Barallton, Ky 23
Bare Hill station, Mont 186
Bare station, Nev 147
Barn station, Cal 123
Barrier, Ky 33
Bartelso, Ill 12
Bartlett, Ill 15
Bassett, Tex 221
Baton Rouge, La 39, 42
Baton Rouge quadrangle, La., traverse in 39–40
Beard, Ky 19
Beatty station, Nev 147
Beaver Creek, Ky 34
Beckleys, Ky 38
Beechgrove, Miss 57
Beechwood, Ky 19, 34, 35
Beechwoods, Miss 57
Belen station, N. Mex 203
Belgium, Wis 121
Bell, Ohio 79
Belle Alliance, La 43
Belmont quadrangle, N. C.–S. C., traverse in 64, 65
Beloit, Wis 118
Belted Peak, Nev 147–148
Bend, The, Ohio 69, 73
Bennington Township House, Ohio 76
Bent, Tenn 99
Benton station, Ill 13
Berky, Ohio 85
Bessemer City, N. C 65
Bethel, Ky 18
Bethel, Mo 62
Bethel, N. C 63
Bettie, Tex 219
Big Beach Creek, Ky 36
Big Chiquesalunga Creek, Pa 95

Page.
Big Creek, Miss 52
Big Meadows station, Cal 170
Big Mulberry Creek, Ark 8
Big Sandy, Tex 219
Big Snowy station, Mont 178
Big Uchee Creek, Ga 5
Birdseye, C. H., work of 175
Birmingham, Mich 50
Bishop station, Cal 159
Bivins, Tex 224
Black Butte station, Mont 183
Black Creek, Ind 24
Black Earth, Wis 116, 117
Blackford station, Ky 25
Black Mountain station, Cal 159
Black Pine station, Mont 186
Blacksburg, S. C 66
Blacks station, Cal 126
Blair Branch, Ga 6
Blanchard, La 45
Blodgett station, Cal 127
Bloomburg, Tex 225
Blossom, Tex 217
Blue Dick station, Nev 173
Blue station, Utah 226
Bogue Chitto Creek, Miss 55
Bolton, Miss 55, 56
Boodle, Ohio 80
Boundary station, Cal 142
Bovina, Miss 51
Bowling Green, S. C 65
Brandon, Miss 51, 52
Brandon quadrangle, Miss., traverse in 50–51
Breese, Ill 11
Breese quadrangle, traverse in 10–12
Brewer station, Cal 170
Briar Ridge, Ky 37
Brick House station, Cal 127
Bridgeville, Ohio 82
Broad River, N. C 66, 67
Broken Horn quadrangle, Wyo., triangulation in 229–235
Brooks, Ky 18
Brownsboro, Ky 20
Browns Crossing, Ill 13
Brownsville, Miss 55
Brownsville, Ohio 86
Bruns, La 40
Brush Creek, Ohio 83
Brushy Creek, Ohio 77
Bryan, Ohio 69
Bryan quadrangle, traverse in 69–70
Bryans Mill, Tex 221
Buchanan quadrangle, triangulation stations in 103–105
Buck Creek, Ind 24
Buck station, Okla 207
Buffalo Creek, N. C 66
Buffalo station, Va 100
Bull Creek, Ind 21
Bullfrog, Nev 155
Bullitts Lick, Ky 23
Bull station, Pa 92
Bull station, Va 101
Busch station, Nev 148
Page.
Bushy Creek, N. C 67
Busti station, N. Y 91
Butter quadrangle, Ohio, traverse in 69, 70
Byerstown, Pa 96
Byram, Miss 52

C

Cache Creek, Cal 176
Cactus Peak station, Nev 148
Caddo, La 45
Caldwell quadrangle, Ohio, traverse in 69, 71
Caldwell station, Va 104
California, traverse in 175–177
triangulation in 122–144, 155–173
California-Nevada boundary posts 173
Cambridge quadrangle, Ohio, traverse in 69, 71
Camp, Tex 218
Campana station, N. Mex 198
Campbell station, W. Va 112
Canas station, N. Mex 198–199
Cane station, Nev 149
Caney Fork, Ky 34
Cap Branch, Mo 59
Carolina and Northwestern Railway 65
Carroll, Ohio 88
Carter station, Va 101
Cartwright, Ky 33
Castle Peak station, Cal 167
Catawba Creek, N. C 65
Catfish Bayou, La 41
Cecil, Ohio 82
Cedars, Ark 9
Cementville, Ind 21
Central City, Ohio 80
Central of Georgia Railway 4, 5–6
Chalfont, Ohio 86
Chalk Mountain station, Nev 149
Chance, N. C 63
Chandler quadrangle, Okla., triangulation in 205–216
Chandler station, Okla 207
Chaney, Ind 21
Chapel Hill, Ala 4
Chapman, R. H., work of 141–197
Charleston, Ark 8
Chattahoochee River, Ala 3, 5
Cherokee Junction, Ark 7
Chesapeake and Ohio Railway 36
Chicago and Milwaukee Electric Railroad 13
Chicago and Northwestern Railway 14
Chicago, Aurora and Elgin Third Rail Electric line 15
Chicago, Burlington and Quincy Railway 16, 59, 61
Chicago Great Western Railway 16
Chicago, Milwaukee and St. Paul Railway 15, 117
Chicago, Rock Island and Pacific Railroad 10
Chicago station, Mont 186
China Grove, Miss 53
Christianburg, Ky 36

Page.
Cincinnnati and Muskingum Railroad 76, 77, 81
Cincinnnati Northern Railroad 69, 84
Clantorf, Wis 116
Clarence, Mo 59, 60, 61
Clarendon station, Pa 92
Clark station, Wyo 232–233
Clarksville, Tex 217, 218, 223
Clarksville quadrangle, Tex., traverse in 217–218
Clay Lick, Ohio 80
Clay quadrangle, traverse in 24–26
Cleveland, Akron and Columbus Railway 75, 76
Cliffside, N. C 67
Clinton, N. C 63, 64
Clouds Rest station, Cal 136
Clover, S. C 65
Clunet, C. A., work of 106
Clyde, Ky 34
Clyman quadrangle, Wis., traverse in 119–121
Coalville quadrangle, Ala., traverse in 2–3
Coffee Hill, Ky 33
Colebrook, Pa 95
College City station, Cal 123
Columbia, Ohio 74
Columbia, Pa 95
Columbia Center, Ohio 87
Columbia station, Nev 145
Columbus, Ga 5
Colusa quadrangle, Cal., triangulation in 122–136
Colusa station, Cal 123
Comite, La 39
Commerce, Mich 49
Cone Butte station, Mont 183
Conesville quadrangle, Ohio, traverse in 69, 71–72
Congdon Peak station, Mont 187
Connelsville, Ohio 83
Conness station, Cal 172
Connors, Ky 38
Consolation, Ky 36
Continental quadrangle, Ohio, traverse in 69, 72
Convenience, Ind 24
Coon station, W. Va 106
Cooper, Ky 33
Cooperdale, Ohio 75
Cooperville, Ky 33
Copay quadrangle, Cal., triangulation in 122–136
Copenhagen, Ill 16
Copper station, Wyo 230–231
Coral Ridge, Ky 18
Corbin station, Cal 127
Cordis station, Okla 213
Corinth, S. C 68
Corne Bayou, La 43
Correy station, Ohio 71
Coshocton, Ohio 73
Coshocton quadrangle, Ohio, traverse in 69, 72–73
Cottonbelt Route 219
Page.
Cottonwood station, Wyo 233
Countsville station, W. Va 112
Coxe Creek, Miss 55
Cox station, Okla 205
Crab Orchard Creek, Ky 26
Craig station, W. Va 113
Crater station, Cal 160
Crescent, La 41
Creswell, Ky 25
Crippen station, Pa 92
Crocodile Lake, La 42
Cross Plains quadrangle, Wis., traverse in 116–117
Croton, Ohio 76
Crowders Creek, N. C 65
Crystal Springs, Miss 57
Cumberland quadrangle, Ohio, traverse in 69, 73
Cupid, Ky 23
Curtis, Cal 176
Curtis station, Cal 128
Cushing stations, Okla 213, 214
Cusseta, Ga 6
Cusseta, Tex 225
Cuthand, Tex 222
Cuthand Creek, Tex 222
Cynthia, Miss 54
Cypress, Tex 221

D.

Dalton, Ky 25, 26
Damiansville, Ill 12
Dangerfield, Tex 218, 222
Darby Camp, Cal 176
Darien, Wis 119
Darwin station, Cal 160
Davisville station, Cal 128
Death station, Cal 142
Deer Mountain station, Mont 194
Defiance, Ohio 73
Defiance Junction, Ohio 73
Defiance quadrangle, Ohio, traverse in 69, 73
De Kalb, Tex 223
Delavan quadrangle, Wis., traverse in 117, 119
Dell, Ky 34
Delrose, Tex 219
Denver, Pa 97
Deranch station, Wyo 229–230
Desert station, W. Va 108
Deshler quadrangle, Ohio, traverse in 69, 74
Des Plaines River 14
Detroit, Tex 217
Devil Peak station, Cal 137
Dewey station, Cal 137
Diamond Lake, Ill 14
Diamond station, Nev 149
Dillon, Ohio 83, 90
Dixon, Miss 56
Dogmelle station, Mont 178–179
Donaldsonville, La 43
Dorseyville station, La 44
Double station, Cal 160
Dovertown, Ohio 81, 90

Page.
Dresden, Ohio 76
Druses Lake, Ill 14
Drygrove, Miss 56, 57
Duncan Hill, Ind 22
Duncans Bridge, Mo 59, 60
Dunnigan quadrangle, Cal., triangulation in 122–136
Dunnigan station, Cal 128
Durlach, Pa 97
Duront, Ohio 83
Dutchtown, La 39
Dyer, Ark 7

E.

Eagle station, Cal 137–138
Earl, N. C 66
East Engle, Ky 35
Easy station, Wyo 233
Echo, Ark 10
Edgerton, Ohio 70
Edmond station, Okla 212–213
Edon quadrangle, Ohio, traverse in 69, 74
Edmund quadrangle, triangulation in 205–216
Edwards, Miss 51
Edwards quadrangle, Miss., traverse in 50–51
Elbeck, Ga 6
El Capitan station, Cal 138
Elgin, Ill 14
Elgin, Joliet and Eastern Railway 14, 15, 16
Elizabeth, Ind 24
Elkhorn, Cal 177
Ellis, J. R., work of 5, 6, 10, 17, 24, 26, 33, 35, 48, 49, 50, 58, 69
Ellis, Ohio 71
Elmville, Ky 35
Emerine station, Mont 187
Enoch station, Wyo 234
Enon, Ky 25
Esparta station, Cal 129
Evans Landing, Ind 24
Ewingsville, Tenn 99
Excello, Mo 59
Excelsior, Ark 8

F.

Fairview station, Cal 129
Fallsburg, Ohio 75, 79
Fence Corner station, Mont 179
Fergus station, Mont 179
Fertility, Pa 96
Filbert, S. C 65
Fincastle quadrangle, Va., triangulation stations in 103–105
Fish Peak station, Mont 188
Fitzsimmons Landing, Ala 5
Five Points, Ala 4
Flat station, Cal 138
Flat Top station, Va 105
Flatwood quadrangle, W. Va., triangulation in 106–116
Flinn station, Okla 209–210
Florence, Cal 170

Page.
Florence quadrangle, Miss., traverse in 50–51, 52–53
Florin, Pa 95
Flournoy, La 45
Floyd quadrangle, Va., triangulation in 100–102
Floyds Fork, Ky 18, 19, 38
Foothill station, Cal 124
Forbush Creek, Ky 34
Foreman, La 39
Forest, Ky 20
Forest Grove, Mo 60
Forks, Miss 57
Fort Mitchell, Ala 5
Fort Smith, Ark 7
Fort Smith quadrangle, Ark., traverse in 6–10
Forty station, Nev 150
Fox Pass station, Mont 179–180
Fox Peak station, Mont 188
Fox Ridge, Ky 18
Frame station, W. Va 106
Franklin station, Cal 124
Frazeysburg quadrangle, Ohio, traverse in 69, 75–76
Fredonia, Ala 3–4
Fredonia, Ohio 77
Fredonia, Wis 121
Freeland, Ohio 82, 83
Frisco Peak station, Utah 226
" Frisco " Railroad 7, 9
Frontenac, Ill 16
Fulton, Ohio 80
Furnace station, Cal 143

G.

Gaffney, S. C 68
Gaffney quadrangle, N. C.–S. C., traverse in 64, 67–68
Gages Corners, Ill 14
Gallup station, Cal 129
Garden, Ark 8
Gassaway, Pa 96
Gastonia, N. C 65
Geismar, La 40
Georgetown, Ind 22
Georgia, traverse in 3, 5–6
Germantown, Ill 11, 12
Gilmer, Tex 219
Gilmer quadrangle, Tex., traverse in 217, 218–219
Gip station, W. Va 107
Girdle station, Okla 207
Glacier Point station, Cal 138–139
Gladewater, Tex 219
Gladstone, Ky 25
Glassrock, Ohio 86
Glensboro, Ky 37
Goddard station, Cal 136
Goddys Corners, Miss 57
Goldfield, Nev 155
Goldfield region, Nev., triangulation in 155, 173–175
Gold Hill, Ala 4
Gold Mountain station, Nev 145, 173–174

Page.
Goodhope, La 39
Goodland, Tex 223
Goodland station, Tex 223
Goshen, N. C 64
Goucher, S. C 68
Goula Bayou, La 44
Grafton, Cal 176
Grand Bayou, La 43
Granite station, Utah 226–227
Grant, Tex 223
Granville, Ohio 77
Granville quadrangle, Ohio, traverse in 69, 76–77
Grape station, Cal 143
Gratiot, Ohio 89
Grays Bend, Cal 177
Great Coharie, N. C 63
Greene Crossing, Miss 54
Greenfield, Miss 53
Greens Mill, Ind 21
Green station, Cal 130
Green station, W. Va 107
Greenwood, Ark 8
Greenwood, La 45
Greggs, Ill 17
Gregory, Ky 33
Grossetete, La 41
Grossetete quadrangle, La., traverse in 40–[illegible]
Grover Hill, Ohio 72
Gudgel, Ky 37
Gunstock station, W. Va 111
Guthrie, Okla 216
Guthrie astronomic pier, Okla 216
Guthrie quadrangle, Okla., traverse in 216
    triangulation in 205–216
Guthrie station, Okla 210

H.

Hackett, Ark 8
Hagers Grove, Mo 61
Haggin station, Mont 188–189
Halleck, Ga 6
Hallsville, Tex 218
Hamler, Ohio 81
Hannibal and St. Joseph Railway 59, 60
Hanover, Ohio 75, 80
Hanover Electric Railroad 80
Harger station, Okla 208
Harrison station, W. Va 110–111
Harrisville, Miss 52
Hartford, Ark 9
Hartford quadrangle, Wis., traverse in 119–120
Hartland, Mich 48
Harvey station, Mont 189
Hatton, Ky 36
Hawkins, G. T., work of 46, 48, 49, 116, 117, 119
Hawkins, Mo 60
Haycock station, Va 100
Hayne, N. C 63
Hebron, Ohio 87
Heckla station, Cal 167
Page.
Heistand, Pa 96
Hellam, Pa 95
Henpeck Corners, Ohio 79
Henrietta, N. C 67
Herder station, Wyo 231
Hesler, Ky 35
Hickory Corners, Ill 14
Hicksville, Ohio 70
Highhill, Ohio 82
Highland, Ill 11
Highland Park, Ky 23
High Sierra region, Cal., triangulation in 155–172
High station, W. Va 107–108
Highwater, Ohio 77
Hilgard station, Cal 156
Hinckley, Tex 223
Hines station, Cal 130
Hobton, N. C 64
Hockersville, Pa 94
Hocking Valley Railway 88
Hodgeson, H. H., work of 205
Hoertz, Ky 18
Holgate, Ohio 81
Holland, Ohio 85
Homer, Ohio 76, 79
Hood, Ky 25
Hooker, Ohio 84, 85
Hooks, Tex 224
Hopevilla, La 39
Hopeville, S. C 66
Horse station, Cal 167
Hot station, Utah 227
Howell quadrangle, Mich., traverse in 46
Howe station, Mont 184
How Ridge, Ky 25
Hubers, Ky 18
Hughes, Tex 218, 222
Hugo, Tex 223
Hummelstown, Pa 94
Humphreys station, Cal 157
Hunters Creek, Mich 47
Hylton station, Va 101–102

I.

Iconium, Tenn 98
Illinois, triangulation in 10–17
Illinois Central Railroad 15, 25, 52, 54, 56
Independence, Cal 160
Indiana, traverse in 17–24
Indian station, Okla 214
Indian Territory-Arkansas boundary 7, 9
Iron station, Utah 227
Isleta, Ohio 80, 81
Isleta station, N. Mex 199, 203
Itasca, Ill 15

J.

Jabez, Ky 34
Jack Pot station, Wyo 234
Jacks Knob station, Ky 33
Jackson, Miss 54

Page.

Jackson quadrangle, Miss., traverse in 50–51, 53–54
Jacksonville, Mo 59
Jamestown, Ga 5
Jamestown, Ill 11
Janesville, Wis 118
Janesville quadrangle, Wis., traverse in 117–118
Jefferson quadrangle, Tex., traverse in 217, 219–220
Jeffersonville, Ind 20, 21, 22
Jewella, La 45
Johnsons Ferry, Miss 53
Johns station, Cal 125
Jonathan Creek, Ohio 90
Jones Creek, La 39
Jonesville, Tex 220
Judith Mountains station, Mont 183
Judith station, Mont 180
Jumbo station, Nev 150
Junction City, Ohio 77

K.

Kaiser station, Cal 156–157
Kansas City Southern Railway 45, 224, 225
Kaweah Mountain station, Cal 171
Kawich station, Nev 150
Kelleyville, Tex 219
Kendall quadrangle, Cal., triangulation in 178–184
Kendall, C. B., work of 2, 5, 17, 20, 22, 35, 39, 40, 50, 63, 64, 94, 96, 98
Kentucky, traverse in 17–38
Kent station, Mont 195
Kenyon station, Cal 161
Kern station, Cal 171
Kerr, Ind 24
Kildare, Tex 220
Kinderhook, Pa 95
Kings Mountain, N. C 65, 66
Kings Mountain quadrangle, N. C., traverse in 64, 65–66
Kings Mountain station, N. C 65
Kite station, W. Va 109
Knight, Ohio 73
Knights Landing, Cal 176, 177

L.

Lafayette, Ala 4
La Joya, N. Mex 204
Lake Forest, Ill 14
Lakeland, Ky 19
Lake Shore and Michigan Southern Railway 85
Lancaster, Ohio 84, 88
Lanesville, Ind 24
Langston station, Okla 210
Lansing, Tex 218
Laplata, Mo 58
Lattimore, N. C 67
Lawn, Pa 95
Leary, Tex 224

Page.

Lees Creek, Ark 7
Lemitar station, N. Mex 204
Lenoir, Tex 223
Lentner, Mo 61
Leonard quadrangle, Mich., traverse in 46–47
Lewiston station, Mont 183
Liberty, Ark 8
Liberty, Tenn 98, 99
Liberty station, Tenn 98
Licking Creek, Ohio 90
Linden, Tex 225
Lindsy's ranch station, Mont 184
Lisman, Ky 26
Little Beach Creek, Ky 37
Little Fabius River, Mo 62
Little Mount, Ky 37, 38
Little Otter quadrangle, W. Va., triangulation in 106–116
Little Thickety Creek, S. C 68
Little Walnut Creek, Ohio 88
Little Whiteoak Creek, Miss 57
Lloyds Corners, Ohio 80
Lochanour, Cal 176
Lock, Ohio 76
Lockwood, Miss 57
Lodi, Tex 220
Logan quadrangle, Ohio, traverse in 69, 77
Lombard station, Ill 15
Lone Mountain station, Nev 145–146, 174
Longrun, Ky 38
Longview, Ala 2
Longview Junction, Tex 218
Los Lunas station, N. Mex 204
Lost Cabin quadrangle, Wyo., triangulation in 229–235
Lucero, N. Mex 232
Louisiana, traverse in 39–45
Louisiana Central Railroad 41, 42
Luis Lopez station, N. Mex 204
Louisville, Ky 18, 19, 23
  survey of 26–32
Louisville and Nashville Railroad 2, 18, 19, 20, 23, 36, 38
Louisville quadrangle, Ky., traverse in 17, 18–19
Lucas ford of Salt River, Ky 38
Luck Creek, N. C 67
Lucknow, Miss 53
Lukens station, W. Va 110
Lula, Miss 55
Lunas, N. Mex 202–203
Lyell station, Cal 168
Lyndon, Ky 19
Lyondale, Ohio 81

M.

McClure quadrangle, Ohio, traverse in 69, 78
McElroys, Ohio 77
McFarland Creek, Ky 34
McLaughlin, Fred, work of 226
McLuney, Ohio 81
McNair, E. L., work of 3, 5, 12, 15, 90
Macon, Mo 59

Page.

Macon quadrangle, Mo., traverse in 58, 59–60
Madison, Miss 53
Madison astronomic station, Wis 116
Magdalena station, N. Mex 204
Magruder station, Nev 174
Mahogany station, Cal 171–172
Mahogany station, Wyo 230
Malden quadrangle, Mont., triangulation in 178–184
Mallon quadrangle, Okla., triangulation in 205–216
Malott, Ky 19
Mal station, Nev 151
Malta, Tex 224
Mansfield, Ark 10
Mansfield quadrangle, La., traverse in 44–45
Marcoot, Ala 4
Maringouin, La 42
Marshall, Tex 220
Martinsburg, Ohio 79
Matamora, Mich 47
Maud, S. C 68
Mayville, Wis 120
Mazomanie, Wis 117
Meadows, Ala 4
Meadows, Ark 7
Mencham, Ill 15
Meas station, N. Y 91
Mechanicsburg, Pa 96
Memphis, Ind 21
Merrick quadrangle, Okla., triangulation in 205–216
Mesa station, Cal 130
Mesa station, Nev 151
Mesecher station, Okla 208
Metamora, Ohio 85
Michigan, traverse in 46–50
Michigan Central Railway 47
Middletown, Ky 19
Middletown quadrangle, Pa., traverse in 94–96
Midland City, Ark 9
Midland Valley and "Frisco" Railroad 8
Midland Valley Railroad 8, 9
Midway, Ohio 73
Milford quadrangle, Mich., traverse in 48
Military Springs, Ky 34
Milk, Ky 38
Mill Creek, Pa 96
Millcreek Mountain, Ark 8
Millersport, Ohio 87
Millsprings, Ky 34
Millstone station, W. Va 109
Millway station, Pa 97
Millwood, Pa 96
Milton, Tenn 99
Milton Grove, Pa 95
Minnora quadrangle, W. Va., triangulation in 106–116
Mississippi, traverse in 50–57
Missouri, traverse in 58–62

Page.

Missouri, Kansas and Texas Railway 45, 218, 219, 220, 221–222
Missouri Pacific Railway 7
Moats, Ohio 69
Moccasin Mountains quadrangle, Mont., triangulation in 178–184
Mohaffeys Ferry, Miss 52
Mono station, Cal 168
Montana, triangulation in 178–196
Montezuma station, Nev 146, 175
Monticello quadrangle, Ky., traverse in 33–34
Monticello station, Cal 131
Montpelier quadrangle, Ohio, traverse in 69, 78–79
Montreal, Ark 9
Monument station, Cal 168
Mooresboro, N. C 67
Mooresboro station, N. C 67
Moore station, Mont 189
Mooringsport, La 45
Morgan station, Cal 161
Mottenville, N. C 64
Mound station, Okla 214
Mount Airy, Pa 97
Mount Eden, Ky 37
Mount Horeb, Wis 116
Mount Pleasant, Miss 57
Mount Pleasant, Tex 221, 222
Mount Pleasant quadrangle, Tex., traverse in 217, 221–222
Mount Salem, Mo 62
Mount Vernon quadrangle, Tex., traverse in 217, 222
Mount Wade, Miss 57
Mount Washington, Ky 18, 19
Mule station, W. Va 109
Mumma station, Cal 131
Myrtistown, La 45

N.

Natchez Bayou, La 43
Natchez Lake, La 43, 44
Neapolis, Ohio 78
Nelson station, Pa 93
Neosho, Wis 120
Nevada, triangulation in 144–155, 173–175, 226, 229
Nevada-California boundary posts 173
New Albany, Ind 22
New Albany quadrangle, Ind., traverse in 17, 22
Newark, Mo 62
Newark, Ohio 80
Newark quadrangle, Ohio, traverse in 69, 79–80
New Baden, Ill 12
New Boston, Tex 224
New Chicago station, Mont 190
New Comerstown quadrangle, Ohio, traverse in 69, 80–81
New Ferry, N. C 67
New Holland quadrangle, Pa., traverse in 96–97

Page.
New Hudson, Mich 48
New Lexington, Ohio 81
New Lexington quadrangle, Ohio, traverse in 69, 81
Newman, Miss 57
Newmans Creek, Miss 56
New Mexico, triangulation in 197–205
New Rosedale, La 42
New York, triangulation in 90–91
Ney, Ohio 69
Nichols station, W. Va 113
Noel station, Va 102
North base station, N. Mex 199–200
North Carolina, traverse in 63–68
Northern Central Railway 95
North Greenfield, Wis 121
North Moccasin Mountains, Mont 182
North Moccasin station, Mont 180–181
Norwich, Ohio 82
Novi, Mich 49
Nowater quadrangle, Wyo., triangulation in 229–235
Nowood quadrangle, Wyo., triangulation in 229–235

O.

Oak Grove, Ark 8
Oak Grove, Ohio 73
Oak Grove, Tex 223
O'Bannon, Ky 20
Ochiles Creek, Ga 6
Ohio and Little Kanawha Railroad 83
Oil Valley, Ky 33
Oklahoma, traverse in 216
  triangulation in 205–216
Olancha station, Cal 161–162
Old Marrottoy, Ky 37
Olive Green, Ohio 71
Ono, Ky 34
Ontarioville, Ill 15
Opelika quadrangle, Ala., traverse in 3–4
Orange, N. C 63
Orangeville, Miss 55
Oregon, Pa 97
Orrs, Tex 218
Osweechee, Ala 5
Orion, Mich 48
Otsego, Ohio 72
Ottawa quadrangle, Ohio, traverse in 69, 81
Otter Creek, Ky 34
Otter Creek, Mo 59
Otter Creek, Ohio 76
Ottoman, Ohio 87
Outville, Ohio 87
Oxford, Mich 47

P.

Paincourtville, La 43
Palestine, Miss 56
Palisade station, Cal 162
Palisade station, Mont 195
Paradise, Pa 96
Paradise station, Okla 215
Paris, Tex 217, 222
Paris quadrangle, Tex., traverse in 217, 222–223
Paris, Texas and Pacific Railway 217
Parnell, Ky 34
Pat, Miss 52
Pataskala, Ohio 87
Patterson Springs, N. C 66
Paulding quadrangle, Ohio, traverse in 69, 82
Peadget, Ark 8
Peak station, Ark 9
Peak station, Utah 227–228
Pearl, Miss 52
Pearl River, Miss 53
Pearson, Miss 53
Peart, Cal 176
Pelahatchee Creek, Miss 53
Pennsylvania, traverse in 94–97
  triangulation in 90, 92–94
Pennsylvania Interurban Railroad 22
Pennsylvania Railroad 73, 98
Penton, Ala 4
Pequea, Pa 96
Perch Creek, Miss 56
Perkins stations, Okla 215
Perry, Mo 61
Petersburg, Ark 13
Peterson station, N. Y 91
Petit Jean River 10
Petty, Ky 37
Pewee Valley, Ky 19
Phee station, Okla 208
Philadelphia and Reading Railway 97
Philipsburg quadrangle, Mont., triangulation in 184–196
Philo quadrangle, Ohio, traverse in 69, 82–83
Pierrepas Bayou, La 43
Pikes Peak station, Mont 194
Pilot Peak station, Cal 139
Pilot station, W. Va 111
Pinchot station, Cal 162
Pinnacle, Tex 219
Pinnacle station, Ark 10
Pioche station, Nev 229
Pioneer, Ohio 78
Pikeville, Wis 14
Pilgrims Rest, Miss 57
Pilot Rock, Ky 33
Piper station, Cal 163
Pittsburg, Tex 219, 221, 222
Pittsburg, Cincinnati, Chicago and St. Louis Railway 21
Plainfield, Ohio 71
Plaquemine, La 41, 44
Plaquemine Bayou, La 41
Plattenville, La 43
Pleasant Hill, Ohio 72
Pleasant Ridge, Ark 10
Pleasant station, Ohio 84
Pleasant Valley, Ohio 75, 82, 89
Pleasant View, Pa 96
Pleasantville, Ohio 87, 88
Plevna, Mo 62
Pocahontas, Miss 55, 56

Page.
Point Lookout station, Mont 190
Poison station, Wyo 231
Polvadera station, N. Mex 200, 204
Pontiac quadrangle, Mich., traverse in 48–49
Poplar station, W. Va 113–114
Porphyry Peak station, Mont 183
Port Allen, La 42
Port Washington quadrangle, Wis., traverse in 119, 121
Potts station, Va 103
Powell station, Mont 194
Prairie Creek, Ark 9
Prairie station, Mont 191
Princeton station, Mont 191
Pritchett, Tex 219
Prospect, N. C 67
Prospect quadrangle, Ind.-Ky., traverse in 17, 19–22
Prosperity, Tenn 99
Providence, Ky 26
Pyramid station, Mont 181

Q.

Quaker Hill station, Pa 93
Quartzite station, Nev 151–152
Quay quadrangle, Okla., triangulation in 205–216
Quay station, Okla 216
Queen City, Tex 224
Quigg station, Mont 192
Quinn, Ky 25

R.

Ransom, Ala 3
Rattlesnake station, W. Va 110
Ravana, Tex 225
Raymond, Miss 55, 56
Raymond quadrangle, Miss., traverse in 50–51, 54–56
Readyville, Tenn 99
Red Lion station, Mont 192
Red Slate station, Cal 157
Reece station, Okla 210–211
Reform, Ohio 75, 80
Reno, Tex 217
Renrock, Ohio 73
Repton, Ky 25
Reservoir station, Utah 234–235
Reveille station, Nev 152
Rexford, Miss 52
Rexs Mill, Ohio 83
Rice, Miss 54
Rich Hill, Ohio 83
Richmond, Wis 119
Rich Patch station, Va 103
Ridge, N. C 65
Riley station, Ky 18
Rio Puerco station, N. Mex 204
Ripley quadrangle, Okla., triangulation in 205–216
Ritters, Ohio 84
Riverview, Ky 23
Riverview quadrangle, Ind.-Ky., traverse in 17, 23

Page.
Robinsons Springs, Miss 54, 56
Rochester quadrangle, Mich., traverse in 49–50
Rockefeller, Ill 14
Rodessa, Tex 225
Roscoe, Ohio 73
Rose Center, Mich 48
Rosedale, La 41, 42
Rosehill, Ind 24, 39
Roselle, Ill 15
Roth station, Cal 132
Rothville, Pa 97
Round Hill station, Wyo 231–232
Round station, Cal 163
Roxbury, Wis 117
Rowland, Ohio 83
Ruble station, W. Va 115
Rumsey quadrangle, Cal., triangulation in 122–136
Runyan, Ind 21
Rushville, Ohio 87
Rutherford, Pa 94

S.

Sac-Fox Agency station, Okla 209
Sac-Fox quadrangle, Okla., triangulation in 205–216
Sacramento, Cal 177
Sadieville quadrangle, Ky., traverse in 35
Saginaw, Ala 2
Saginaw, Ala 2, 3
Sago station, Ohio 72
St. Gabriel, La 40
St. Louis and San Francisco Railroad 222–223
St. Louis Southwestern Railway 219, 221
St. Marks, Ga 5
St. Matthews, Ky 19
Salem, Ala 4
Salemburg quadrangle, N. C., traverse in 63–64
Salem, Ala 4
Salt River, Ky 38
Salt River, Mo 60
San Acacia Mesa station, N. Mex 204
San Antonio station, N. Mex 20
Sandersburg, Pa 96
Sanders station, N. Mex 200–201
Sapphire quadrangle, Mont., triangulation in 184–196
Schoeneck, Pa 97
Scotts, Ky 38
Scott station, Cal 132
Scottsville, Tex 220
Sellersburg, Ind 21
Sentinel Dome station 139
Seward, Ohio 85
Seymour Ferry, La 41
Seymourville, La 44
Sharon, Ohio 70
Sharp Hill, Ohio 83
Shawneetown quadrangle, Tex., traverse 217, 223
Shearer Valley, Ky 33

Page.
Sheep station, Cal 163
Sheet Line, Nev 152
Shelbina, Mo 60
Shelbina quadrangle, Mo., traverse in 58, 61–62
Shelby, N. C 66, 67
Shelby quadrangle, Mo., traverse in 64, 67
Shelbyville, Ky 36
Shelbyville, Mo 62
Shelbyville quadrangle, Ky., traverse in 35, 37
Shelbyville quadrangle, Mo., traverse in 58, 61–62
Shepherdsville, Ky 18, 23
Sherman, Ohio 88
Shiloh, Mo 62
Shoal Creek, Ill 12
Shoal House, Ohio 87
Shopiere quadrangle, Wis., traverse in 117, 118
Short Hill station, Va 105
Short Mountain station, Tenn 98
Short Peak station, Mont 185
Short station, Okla 211
Shreveport, La 45
Shreveport quadrangle, La., traverse in 44, 45
Silver station, Cal 158
Simms, Tex 221
Simpsonville, Ky 38
Sixmile Creek, Ohio 72
Skaggs station, Mont 181
Skylight, Ky 20
Sleterville, Ky 35
Smettzer, Ark 7
Smith, Miss 51
Smith, Tex 219
Smithville, Ky 19, 38
Smokestack station, Cal 125, 176
Snowball, Ohio 82
Snug's ferry, N. C 67
Socorro Peak station, N. Mex 201
Socorro station, N. Mex 205
Solon, Ind 21
Somerset, Ohio 86
Sonora, Ohio 82
South Base station, N. Mex 201
Southern Pacific Railway 177
Southern Railway 12, 22, 23, 65, 66
South Moccasin Mountains station 183
South Moccasin station, Mont 181–182
South Park, Ky 18
Spann, Ky 33
Speeds, Ind 21
Spencer quadrangle, W. Va., triangulation in 106–116
Spencer station, W. Va 114
Split Mountain station, Cal 158
Springdale, Tex 224
Springs station, Utah 228
Staats station, W. Va 114
Stanley, Tex 218
Star, Miss 52
Starr, Ky 25
Starr King station, Cal 140
Stephens Creek, Ga 6

Page.
Steubenville, Ky 34
Stevens station, Cal 132–133
Stewart, B. D., work of 141
Stocker station, Va 100–101
Stokes, Ky 34
Stonewall station, Nev 153, 175
Stony Brook, Pa 95
Stony Ridge, Ky 26
Stovall station, Cal 125–126
Stovetown, Ohio 83
Stringtown, Ohio 81
Strong station, Okla 211
Stryker quadrangle, Ohio, traverse in 69, 84
Stuart Methodist Episcopal Church station, Va 102
Stuart quadrangle, triangulation in 100–102
Stuart station, Okla 209
Sugargrove quadrangle, Ohio, traverse in 69, 84–85
Sugarhouse, La 43
Sugar Loaf station, Mont 193
Sugar Loaf station, Va 104–105
Sugar station, W. Va 108
Sullivan, Ky 25
Sulphur Bridge, Tex 224
Sulphur River, Tex 221
Summit, Ohio 77, 87
Sumpter, Ky 33
Sundale, Ohio 82, 83
Susie, Ky 34
Susquehanna River 95
Swanton quadrangle, Ohio, traverse in 69, 85–86

T.

Tallahala Creek, Miss 56
Tallula quadrangle, Ill., traverse in 12–13
Tatum, Sledge, work of 44, 217
Taylorsville, Ky 38
Taylorsville quadrangle, Ky., traverse in 35, 38
Teague Bridge, Ala 3
Telescope Peak station, Cal 144
Tenark, Tex 224
Tennessee, traverse in 98–99
Terry quadrangle, Miss., traverse in 50–51, 56–57
Texarkana, Tex 224
Texarkana quadrangle, Tex.-La., traverse in 224–225
Texas, traverse in 217–276
Texas and Pacific Railway 41, 42, 43, 45, 217, 218–219, 220, 224
Thickety, S. C 68
Thickety Creek, S. C 68
Thickety Mountain, S. C 68
Thomas, Mich 47
Thomasville, Miss 52
Thomville quadrangle, Ohio, traverse in 69, 86–87
Three Sisters station, Cal 164–165
Thurston, Ohio 87
Thurston quadrangle, Ohio, traverse in 69, 87–89

Page.
Timber Creek, Ky 37
Timber station, Nev 153
Timpahute station, Nev 146
Ting, Ky 19
Tin station, Cal 144
Toledo and Ohio Central Railway 80, 87
Tolicha station, Nev 153–154
Tome station, N. Mex 203
Tom station, Cal 164
Toray, N. C 65
Touchstone, Miss 52
Trail station, Cal 172
Trampton, Ohio 75
Tribune, Ky 25
Trinway, Ohio 76
Tryon station, Okla 209
Tucker, L. E., work of 13
Tucker, Ky 19
Tufted Pine station, Mont 182
Tumballs Creek, Miss 52
Tunnel Hill, Ohio 75
Turkey Ridge, Ky 33
Turner station, Va 102
Turtle Creek, Wis 119
Turututu station, N. Mex 202
Tushar station, Utah 228

U.

Union, Miss 53
Union, Ohio 77
Upatoie, Ga 5, 6
Urquhart, C. F., work of 122, 136, 155
Utah, triangulation in 226–228
Utica, Mich 49
Utica, Ohio 79

V.

Valley station, Cal 140
Van Buren, Ark 7
Vandalia Railroad 11
Vandyke, Ky 37
Vantines, N. C 65
Verona, Wis 117
Vesta, Ark 8
Vesta, Ind 21
Vian, Pa 94
Vicksburg, Miss 57
Vicksburg quadrangle, Miss., traverse in 50–51, 57
Vintage, Pa 96
Violet Chapel, Ohio 88
Virginia, triangulation in 100–105
Vivian, La 45
Vulcan station, N. Mex 197–198

W.

Wabash Railroad 58, 73, 74
Wagram, Ohio 88
Wait, Ky 33, 34
Wakaton Creek, Ohio 75
Wakatomika, Ohio 76
Wallace station, Okla 212

Page.
Walnut Hill, Ky 25
Walton quadrangle, triangulation in 106–116
Ward, Ark 9
Warm Spring station, Mont 185
Warren station, Mont 193
Washington, Cal 177
Washoe station, Mont 185
Waskom, Tex 220
Water Canyon station, N. Mex 205
Waterford, Ky 38
Waterville, Ohio 86
Watrous quadrangle, Wyo., triangulation in 229–235
Waucoba station, Cal 164
Waukegan, Ill 14
Waukegan quadrangle, Ill 13–14
Waukesha quadrangle, Wis., traverse in 119, 121
Wauseon quadrangle, Ohio, traverse in 69, 89
Webster station, Cal 126
Weed station, W. Va 115–116
Wellom, Ohio 86
Weedy station, W. Va 115
Westbend quadrangle, Wis., traverse in 119, 120
West Carlisle, Ohio 75
West Earl, Pa 97
West Lafayette, Ohio 71, 72, 80
West Mound station, Mont 185
West Point, Ga 3
West Point, Ky 23
Westport, Ky 20, 21
West Rushville, Ohio 87
West Virginia, triangulation in 106–116
Wheaton quadrangle, Ill., traverse in 15–17
Wheelbarrow Peak station, Nev 154
Wheeling and Lake Erie Railroad 76, 82, 90
Whitecastle Lumber Company Railroad, La 44
Whitecastle quadrangle, La., traverse in 43–44
Whitehouse, Ohio 78
White Mountain South station, Cal 169
White Mountain station, Cal 169
Whiteoak Creek, Ky 34
Whiteoak Creek, Miss 57
White Oak Creek, Tex 222
White Pine station, Nev 154–155
White Plains, Ala 4
White Top station, Cal 165
Whiteville, Ohio 85
Whitfield, Ky 19
Whitney station, Cal 165–166
Widder station, Ohio 81
Wilburn, Ohio 81
Wilcox station, Pa 93
Wilkin, Tex 219
Wilkinsville, S. C 68
William Bayou, La 41
Williamson station, Cal 166
Williams station, Cal 126
Willow station, Mont 196

Page.

Wilma station, Mont 194
Wills Creek, Ohio 72
Wilsons Creek, Ky 25
Windmill station, Cal 133
Windmill station, Mont 183
Wingard station, Okla 212, 216
Winters stations, Cal 133, 134
Wisconsin, traverse in 116–121
Wisconsin Central Railway 14
Wolf Creek, Ky 34
Wolf Creek, S. C 66
Woodland, Cal 176
Woodland quadrangle, Cal., triangulation in 122–136
Woodland stations, Cal 134
Woodland station, Wis 120
Woodlawn, Mo 60
Wrightsville, Pa 95
Wyoming, triangulation in 229–235

Y.

Yankee Bush, Pa 94
Yates, Ky 35
Yazoo and Mississippi Valley Railroad 40, 54
Yellow Leaf Creek, Ala 2, 3
Yellow station, Nev 155
Yerkes observatory, Wis 119
Yolo, Cal 176
Yolo northwest base station, Cal 135
Yolo southeast base station, Cal 135–136
Yolo station 134
York, Pa 96
York Center, Ill 16
Yosemite Point station, Cal 140–141
Yosemite quadrangle, Cal., triangulation in 136–141

Z.

Zanesville, Ohio 82, 90
Zanesville and Western Railway 86
Zanesville quadrangle, Ohio, traverse in 69, 89–90
Zinc, Ohio 88
Zion, Ark 10
Zion City, Ill 14
Zula, Ky 33

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[Bulletin No. 310.]

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